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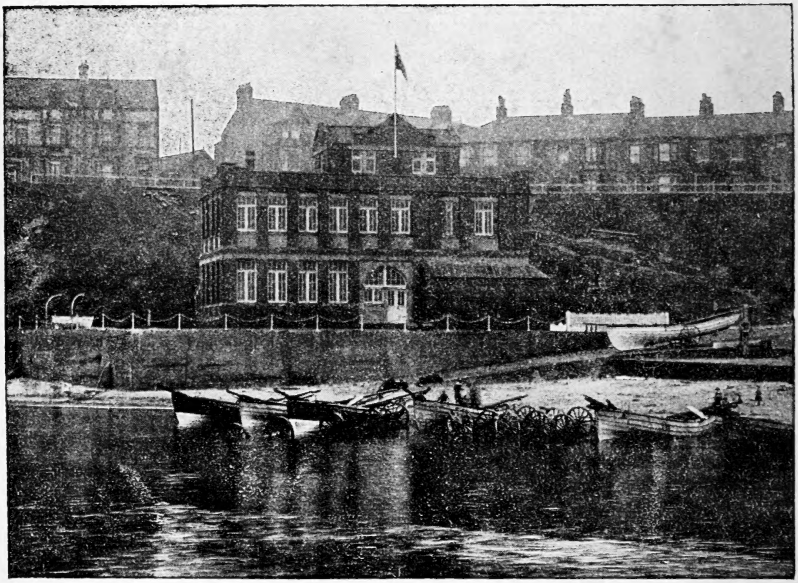

DOVE MARINE LABORATORY, CULLERCOATS

New Series, II.

# DOVE MARINE LABORATORY,

## CULLERCOATS, NORTHUMBERLAND.

# REPORT

For the year ending June 30th, 1913.

Edited by ALEXANDER MEEK,

Professor of Zoology, Armstrong College, in the University of Durham,
and
Director of the Dove Marine Laboratory.

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# SUMMARY AND GENERAL REPORT.

The new series of which this is the first number is continuous with the sixteeen annual reports published by the Northumberland Sea Fisheries Committee. An arrangement has been made whereby the publication of the report will be undertaken by Armstrong College, and this will allow of the inclusion of papers other than those of purely fishery interest.

The results of an investigation on the Prawn or Norway Lobster Fishery of North Shields are described by Mr. Storrow. The Norway Lobsters are caught off the coasts of Northumberland and Durham, and the increasing importance of this branch of the trawl fishing industry of North Shields, and the seasonal variation are indicated by a consideration of the statistics. From an examination of some 7,000 specimens the contrast in size between the males and females, the scarcity of the females in the summer, the relatively same period of incubation as in the case of the common lobster, and similar facts have been made out. Spawning is probably biennial. The number of eggs carried varies with the size. The smallest berried specimen found measured 8 cm. The analysis has brought out also interesting details with regard to the casting season, and the influence of tides on the catches.

The experiments in lobster culture have been continued, and have shown the value of filtered water, and also of large tanks. Two young lobsters, now nearly a year old, have been successfully reared from the egg.

In the Annual Report of Proceedings under Acts relating to Sea Fisheries for 1910, issued in 1912, there appeared a paper with the title Memorandum on the Size, Sex and Condition of Lobsters. This gave the results of an investigation instituted by the Board in 1907 with a view to determining the best means of protecting lobsters. A critical review of this paper is published here, objection being especially taken to the statements that from the point of view of protection, the berried lobster is not so valuable as raising the size limit, and that the stripping

of the berried lobsters cannot be discovered. The Northumberland Sea Fisheries Committee is convinced that the protection at present given in the district to the berried lobster is on the right lines and desires to see the berried lobster generally protected all round the coast.

A brief statement is also made as to the protection of the crab in continuation of similar papers in previous reports. A consideration of the available facts shows that a close time from October 1st to December 31st is desirable on the Northumberland coast and inferentially also in the North Eastern and Eastern districts. An enquiry should be made apropos of this to find out the main casting season of crabs in other districts.

H. Morris-Airey, M.Sc., contributes a paper, the outcome of experiments which he has been making on the south pier at the mouth of the Tyne on the nature of the waves which damage the crab pots of the fishermen.

The experiment in mussel culture is still being continued at Holy Island. There can be no doubt that the scaup there could be made to support a large mussel farm, and the only important matter to settle is how to set in motion the machinery which would create a new industry for some of the men and women at Holy Island, and which would also result in the encouragement of line fishing on the coast.

Much interest was aroused last autumn in the catches of herring made by trawlers. Just after the close of the usual herring season a number of North Shields trawlers fitted their boats with a modified trawl net and commenced fishing for herring. They were successful in discovering a large shoal of herring which had assembled for spawning purposes. Through the kindness of Mr. Purdy samples were obtained from time to time during the period when the shoal appeared off the coast. At the commencement of the period the herring passed from the mattie to the full condition, and, towards the end, before they dispersed among the herrings were included a large number of "spents." The school was therefore a late spawner and very like in general appearance and even in detail to the herring landed at and after this season at the southern ports of the North Sea. The catches were landed in good condition, being only inferior to drift net herring in appearance due to loss of scales. They were cured quite successfully.

As in previous years the plaice spawned in the tanks of the laboratory, and this year an attempt was made, by isolating examples and making notes of the general nature of the spawning, to see whether the plaice exhibited the periodicity in spawning observed last year in the case of the cod. This was found actually to be the case, although the periodicity was not quite so constant as in the cod. The observations rendered possible a short account of the effect of temperature on the rate of development. During the period of spawning demonstrations on the development of the plaice were given to the public and to fishermen by Mr. Storrow.

The material gathered last year to illustrate the development of the cod has been utilised to prepare a detailed statement on the embryology of this form. This will be published elsewhere.

With the aid of the "Evadne" material has been gathered at various stations from Cullercoats to St. Andrews. The general results are given under the title "Biological Investigations."

The "Evadne" was also used to obtain samples of the water in the Tyne. The samples were chemically examined by Professor Bedson, bacteriologically examined by Professor Hutchens, and special samples were taken also to indicate the general plankton under the conditions when the experiments were made. It is an investigation which well deserves to be repeated during the summer when the water is low.

Herbert W. R. Haselhurst publishes in this report a paper on the composition of our common seaweeds, and draws attention particularly to the manurial value of what is at present allowed to waste. The work was done at the Laboratory.

In connexion with renewed complaints as to the destruction of salmon and salmon nets by seals, an account is given of the colony at the Farne Islands. It appears to be desirable to obtain further proof of the destruction before considering methods of reducing the numbers of the seals.

Sandeels are liable to periodical destruction on an enormous scale, and Mr. W. Mark Pybus records here the observations he has made on this subject at Newbiggin and at Warkworth.

Attention is drawn to the records which appear under "Faunistic Notes."

Tables have been occupied by Prof. F. J. Cole, Major Bishop, Mr. Haselhurst, and several members of the Northumberland Coast Club. The Laboratory has been visited by several members of the permanent staff of the Board of Agriculture and Fisheries, by Professor W. A. Herdman, Liverpool, by Mr. Minchin of the British Sea Anglers' Society, by Mr. T. Kitahara of the Fishery Department of Japan, and others. The aquarium has been visited by various institutions and schools.

The only attempt at experimental trawling was made on June 29th, 1911. As soon as the net was launched, it was caught by an anchor or something of the kind, and in the efforts to release it the beam was broken. It was felt at the same time that although the "Evadne" could do the work, it was a heavy strain, and the crew was too limited to carry it on with the efficiency which would produce results as good as those to be obtained with a larger vessel. This side of the work has therefore been temporarily suspended. It will perhaps be advisable to allow it to remain in that state until we see what grant will accrue to this district from the Development Commissioners, and what proposals are made by the Board for a more thorough-going investigation into the resources of the district, and into such problems as migrations, the herring, undersized fish, and so on, when the grant is distributed. It is possible then that a suggestion will be made for parallel investigation with similar outfit and conducted under similar conditions generally.

As was stated in the reports for the last two years application was made for a grant in aid of the fishery investigations done at the Laboratory from the funds at the disposal of the Development Commissioners. The general scheme which the Board of Agriculture and Fisheries had prepared and sent to the Commissioners has not yet been approved, but we are assured that the application made on behalf of the Laboratory is included, and that the Laboratory will be called upon to take part in the general scheme of investigation. In the meanwhile, certain interim grants have been made to Committees and Laboratories in England. Northumberland is not included in this list. At the meeting of representatives of Fisheries held on June 25th the reason for this omission was asked, and the reply given by the President was that we had applied for new work, and the grants were made for work which was being carried on at present.

The answer is difficult to understand, since we have been carrying on fishery investigations for over 16 years in Northumberland, and a few minutes before it was given, representatives stated that because of the interim grant which had been obtained they had been able to *start* investigations.

The application we sent in did not specify lines of proposed investigations, for we were informed by the officials of the Board that such would not be necessary seeing that the Board was preparing a general scheme, that an application would be made on our behalf in that scheme, and that we should be consulted as to the details. But as is manifestly plain, whatever is the real reason, the treatment we have received is far from reassuring, and to prevent further misconception, if possible, we are about to send to the Treasury a fresh application. This will give in outline the nature of the work we have done and of the work with which we are at present occupied, and it will include a scheme for its continuation and expansion.

ALEXANDER MEEK.

*29th June, 1912.*

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Since the above was printed we have received from Dr. T. W. Fulton, of the Scottish Fishery Board, particulars of the recapture of the following marked fish. They were all marked and liberated on 28th July, 1909, at Skate Roads (S. of Holy Island).

PLAICE.

| No. | Sex. | 1911. | Captured. | Size when Liberated. | Size when Captured. |
|---|---|---|---|---|---|
| 335 | m | 13th April | 25 miles E.S.E. of Aberdeen in 35 fms. | 26 cm. | 36·6 cm. |
| 305 | f | 7th May | 26 ,, S.S.E. ,, ,, | 26 ,, | 45·8 ,, |
| 311 | m | 5th Sept. | 45 ,, E.S.E. of Bass Rock... ... | 23 ,, | 36·8 ,, |

TURBOT.

| No. | Sex. | 1912. | Captured. | Size when Liberated. | Size when Captured. |
|---|---|---|---|---|---|
| 350 | m | 28th June | 30 miles E.$\frac{1}{2}$N. of Isle of May in 25-27 fms. | 29 cm. | 49·5 cm. |

# THE PRAWN (NORWAY LOBSTER, *Nephrops norvegicus*), AND THE PRAWN FISHERY OF NORTH SHIELDS.

By B. STORROW.

It is a well-known fact that the Norway Lobster was an extremely rare crustacean until trawling was introduced on Tyneside. Since then it has formed an interesting and valuable part of the catches landed at North Shields. Howse* records finding nearly two bushels of Norway Lobsters on board a trawl boat in 1858, and Mennell† draws attention to the large number which had been caught since the introduction of trawling in the district, and to their being sold in the fish shops, but states that this lobster is not so abundant as the common lobster.

Professor Meek suggested in April of last year that periodic examination of the catches of Norway Lobsters might yield information which would enable us to state a little more accurately some of the facts relating to the condition of this crustacean landed at North Shields, and caught off the coast of Northumberland and Durham.

The following figures, obtained from the statistics of the Board of Agriculture and Fisheries, show the total quantities of Norway Lobsters landed at North Shields since the year 1895. It is evident from these that the fishing for Nephrops is of increasing importance, and although the catch for 1911 was below that of the two previous years, there is nothing to show that the species is decreasing in numbers. In certain of the years—those marked with an asterisk—are some months for which no figures are available, and none are to be obtained for 1896. Now records are kept with more care, and will therefore be of more value for future reference.

| | Cwts. | Value. £ | | Cwts. | Value. £ |
|---|---|---|---|---|---|
| 1895 | 9,339 | 3,646 | 1904 | 6,693 | 2,615 |
| 1896 | — | — | 1905 | 9,420 | 3,646 |
| 1897 | 746* | 630 | 1906 | 11,822 | 5,183 |
| 1898 | 1,763* | 1,407 | 1907 | 10,820 | 5,372 |
| 1899 | 3,781 | 2,487 | 1908 | 9,630 | 4,579 |
| 1900 | 3,069 | 2,058 | 1909 | 13,109 | 5,457 |
| 1901 | 3,483 | 2,659 | 1910 | 14,768 | 5,653 |
| 1902 | 1,399* | 1,021 | 1911 | 11,987 | 4,880 |
| 1903 | 1,295* | 1,192 | | | |

* Trans. Tyneside Nat. Field Club, Vol. V, p. 59.
† Trans. Tyneside Nat. Field Club, Vol. V, p. 154.

Monthly Catches.—From the same statistics Table I. has been obtained. The quantities landed each month of the year during a period of five years, 1907-1911, are given. From these the mean quantity for each month has been calculated in order to show the months during which the greatest quantities are landed. These are clearly from September to January. The smallest quantities being landed from March to July.

TABLE I.

| | 1907. | 1908. | 1909. | 1910. | 1911. | Mean. |
|---|---|---|---|---|---|---|
| January ... ... | 1,130 | 767 | 1,609 | 1,748 | 1,056 | 1,262 |
| February ... ... | 437 | 527 | 835 | 1,010 | 924 | 747 |
| March ... ... | 385 | 513 | 729 | 1,015 | 493 | 627 |
| April ... ... | 188 | 243 | 558 | 424 | 584 | 399 |
| May ... ... ... | 136 | 141 | 110 | 202 | 220 | 162 |
| June ... ... | 523 | 131 | 399 | 849 | 282 | 437 |
| July ... ... ... | 481 | 305 | 785 | 1,046 | 468 | 617 |
| August ... ... | 786 | 768 | 787 | 1,683 | 890 | 983 |
| September ... ... | 1,116 | 1,086 | 1,653 | 1,987 | 1,481 | 1,465 |
| October ... ... | 2,172 | 1,677 | 2,214 | 1,512 | 1,537 | 1,822 |
| November ... ... | 1,964 | 1,836 | 2,141 | 1,743 | 2,217 | 1,980 |
| December ... ... | 1,502 | 1,636 | 1,289 | 1,549 | 1,835 | 1,562 |

By means of statistics, kindly supplied by the Board of Agriculture and Fisheries, it is possible to show that the results obtained above are not altogether due to an increase in the number of vessels fishing for Nephrops during the winter months. In Table II. the quantity in cwts. landed during each month of 1911 by vessels which have been absent on a voyage not exceeding one day in duration, and the number of such landings are given. From these the mean quantity for each landing of one day's catch has been determined. It will be seen that, on the whole, during the months when the greatest quantities were landed the greatest catches were made by individual boats. The figures are taken for vessels which have been absent on a voyage not longer than one day, because in summer when the trawlers are absent more than one day it is seldom that the whole of the time is spent on the prawn ground, this region generally being fished the day before landing.

## TABLE II.

CATCHES FOR ONE DAY'S FISHING FOR ONE BOAT FOR EACH MONTH OF 1911.

| | Cwts. | No. of Landings for Vessels away 1 day from port. | Mean. |
|---|---|---|---|
| January ... ... | 559 | ... 69 ... | 8·1 |
| February ... ... | 221 | ... 32 ... | 6·9 |
| March ... ... ... | 160 | ... 45 ... | 3·6 |
| April ... ... ... | 244 | ... 43 ... | 5·7 |
| May ... ... ... | 148 | ... 65 ... | 2·3 |
| June ... ... ... | 230 | ... 102 ... | 2·3 |
| July ... ... ... | 313 | ... 109 ... | 2·9 |
| August ... ... | 758 | ... 126 ... | 6·0 |
| September ... ... | 1,372 | ... 97 ... | 14·1 |
| October ... ... | 1,191 | ... 114 ... | 10·4 |
| November ... ... | 1,545 | ... 115 ... | 13·4 |
| December ... ... | 1,187 | ... 100 ... | 11·9 |
| TOTAL ... ... | 7,928 | ... 1,017 ... | 7·8 |

FISHING GROUND.—The local fishing ground extends from Coquet Island to between Seaham and Hartlepool, at a distance of 10 to 16 miles from the shore, the bottom being chiefly of mud. The widest part of this area, which is about 200 square nautical miles in extent, is found N.E. by E. of the Tyne, in 35 to 42 fathoms. No Norway Lobsters are caught inside of 33 fathoms. They are few in number in the region off Coquet Island, and are most abundant between Newbiggin and Seaham.

For the nature of the bottom and surface life obtaining on this ground, "Biological Investigations" in this report should be consulted. The material was taken when at sea in July and August. The catches of edible fish made each time the trawl was fishing are also given. It is interesting to note in this connexion that during October and November crabs were plentiful on the ground. Some of those caught were examined, and it was found that the greater number consisted of females, which in October were recovering from being soft. In November the males had increased in numbers, and were also in a soft or white-footed condition.

MATERIAL EXAMINED.—Mr. Purdy, the well-known owner of steam trawlers, three of which are constantly fishing on the local prawn ground, has been interested in this matter, and has kindly allowed me to make measurements on his vessels when landing their catches at North Shields fish quay, and

also to take voyages on the boats. Mr. Brown, skipper of the "Raider," saved me a basket of prawns whenever I asked for it, and it is from these samples, taken without any sorting, and therefore being representative of the catch, that by far the greater part of the observations has been made.

The material which has been examined consisted of samples of catches and of total catches, the latter being examined when at sea with the trawler, and in three cases, at the fish quay at North Shields. These three catches were small and allowed the examination to be made in time for the catch to be sold before the boat returned to sea.

Samples have been examined from May, 1911, to April, 1912, but no observations were made during March, 1912, as owing to the coal strike fishing was very irregular, and it was impossible to tell when any boat was going to land her catch.

Three voyages have been made to the prawn ground, two on the "Raider" and one on the "Ranter." During these trips a number of measurements was made, and material was collected to show the nature of the life on the fishing ground. From observations then made I feel sure that the samples examined at the fish quay are true samples of the catches made.

The length of each individual from the rostrum to the end of the telson was measured to the nearest centimetre, that is, any between 12·5 and 13·5 cm. were recorded as being 13 cm. Sex was determined, and in the case of females it was noted whether they were berried or non-berried. A record was also kept as to the number and size of males and females which were in a soft condition or recovering from casting. It has also been possible to obtain a number of records of males having spermatophores leaving the deferent ducts or in the penes.

Size.—Table III. gives the size and number of males, non-berried females and berried females found in each sample, and these are summarised in Table IV. It will be observed that the males may grow to 22 cm., but that no female has been obtained exceeding 17 cm. The smallest individuals which have been found are a male of 6 cm. and a female of 5 cm. The mean size for males and females is found to be 15·6 and 12·4 cm. respectively. This difference in size is probably due to a difference in the intervals between casting, which in females will

be determined by the time elapsing between casting and the hatching of the young, whereas, in males, casting may take place annually or at less intervals.

Norway Lobsters which are less than 11 cm. in length are of little if any market value, and these are found to be only about 6 per cent. of the number examined. The general opinion amongst the fishermen is that most large prawns are caught north of the Tyne, and that the smaller ones are most abundant in the neighbourhood of Seaham.

Proportion of Males, Females and Berried Females.—Table V.—Altogether 7,686 Norway lobsters have been examined. Of these, 73·5 per cent. were males, 26·5 per cent. were females, and the percentage of berried females in the total number of females was 5·8. The percentages of females and berried females are small when taken for the whole of the period during which the observations have been made. But these percentages are found to vary throughout the year, and although in no month have the females been found to exceed the males in number, yet during the winter months the number of females increases and sometimes almost equals that of the males. At this time the percentage of berried females is least. From individuals kept in captivity it is clear that the eggs are carried during the winter, and therefore the berried females exist although not caught by the trawl. It is probable then that the females may exceed the males in number, and that habits of which no knowledge at present is obtainable bring about the small percentages of females in summer and of berried females in winter.

Hatching and Period of Incubation.—Berried females have been found with the young leaving the egg or nearly ready to do so in the months May to September, the highest percentage being in June. In July, August, September and October by far the greater number of berried females carried recently spawned eggs, the highest percentage being found in September. For particulars see Table V. If June and September be taken as the chief months for hatching and spawning, the period of incubation is probably about nine months.

The eggs on being spawned are dark green in colour. Later they change to a lighter green, and with the growth of the

embryo, which becomes pink as it develops, the quantity of light green yolk decreases until the eggs are of a transparent pink.

On 3rd November, 1911, twenty-nine berried females were placed in a tank in the Laboratory in order to procure larval stages. Of these, twenty-eight had dark green eggs, and one had a little more than half the yolk replaced by the pink embryo. This latter, the eggs of which would probably have hatched out in the spring, died a few days afterwards. Two others died on 8th November, and the eggs were still dark green. On 21st December a number of those still living were examined, and all had light green eggs. The eggs were fewer in number, and it is probable that they had been removed by the females. This has been noticed when berried females were kept in small tanks. A further examination was made on 26th April, 1912. Some carried few eggs. In the majority the eggs were well advanced and beginning to turn to a transparent pink, a small quantity of green yolk remaining. In two cases the eggs were of a light green colour, but the embryo had the eyes showing quite distinctly, and the yolk did not occupy more than one-third of the egg.

Frequency of Breeding.—From the high percentage of non-berried females found during the winter months, it is evident that breeding does not take place annually. On 31st August, 1911, six non-berried females were placed in a tank in the Laboratory, and no eggs had appeared by the following April.

In Table VI. will be found particulars relating to the condition of the ovaries of nine non-berried females, eight of which were examined in July. The size of the eggs in the ovaries, which were large in bulk in Nos. 1 and 2, suggests that spawning was approaching, and if the colour and size of the ovary be any criterion, this may be the same in Nos. 7 and 8. These latter contained spermatophores in the spermatheca, which is situated between the fourth and fifth pairs of walking legs. In the case of No. 9, which was examined in October, it will be seen that the eggs are very small, and some considerable time must have elapsed before they were ready to be spawned. Although no measurements were made of the eggs in the ovaries of the remaining four, the ovaries were quite small in bulk and

far from being ready for spawning. No. 3 had fragments of egg capsules on the setæ of the swimmerets, and from this hatching had probably taken place quite recently.

Number of Eggs and their Size.—The number of eggs carried by nine berried females, ranging in size from 12 to 16 cm., has been determined by counting. The number is found to vary according to the size of the female, except in an individual of 15 cm., which carried a smaller number than two measuring 13 and 14 cm. respectively. The eggs carried were in all cases dark green in colour.

| No. | Examined. | | | Length. | | No. of Eggs. |
|---|---|---|---|---|---|---|
| 1 | 26th August, 1911 | ... | ... | 12 cm. | ... | 1,357 |
| 2 | 26th August, 1911 | ... | ... | 12 cm. | ... | 1,543 |
| 3 | 26th August, 1911 | ... | ... | 12 cm. | ... | 1,681 |
| 4 | 2nd September, 1911 | ... | ... | 12 cm. | ... | 1,669 |
| 5 | 26th August, 1911 | ... | ... | 13 cm. | ... | 1,766 |
| 6 | 2nd September, 1911 | ... | ... | 13 cm. | ... | 2,588 |
| 7 | 26th August, 1911 | ... | ... | 14 cm. | ... | 2,640 |
| 8 | 26th August, 1911 | ... | ... | 15 cm. | ... | 2,340 |
| 9 | 19th October, 1911 | ... | ... | 16 cm. | ... | 4,106 |

In all cases the ovaries were quite small in bulk, and extended to the beginning of the second abdominal segment. They were light yellow in colour in Nos. 1 to 8, No. 1 containing a small number of dark green eggs situated over the left oviduct. In No. 9 the ovaries were light green, and the eggs they contained were quite small, a number of them being of the following sizes, ·66 × ·54, ·66 × ·46, ·62 × ·46, ·58 × ·58 and ·5 × ·5 mm.

The spermathecæ of Nos. 1, 3, 4, 5, 6 and 8 were examined, and were found to contain a few sperms situated above a hard yellow substance.

Some of the eggs carried by Nos. 2, 5 and 7 were measured. The commonest size was 1·5 × 1·4 mm. Others were found to measure 1·6 × 1·5, 1·6 × 1·4, 1·5 × 1·5 and 1·4 × 1·3 mm.

Maturity of Males and Females.—A number of males with spermatophores leaving the deferent ducts or in the penes have been observed, the smallest being 10 cm. in length. The following are the months when they were found, and the sizes

are given in centimetres. From the observations it appears that the males may become mature almost throughout the year.

| | | |
|---|---|---|
| January, 1912 | ... | 17, 17 cm. |
| February... | ... | 12, 13, 14, 14 cm. |
| April ... | ... | 10, 14 cm. |
| July, 1911 | ... | 17, 17, 18 cm. |
| August ... | ... | 15, 16, 16, 16, 17, 17, 17, 18, 18, 18, 18, 19, 21 cm. |
| September | ... | 14, 14, 15, 16, 17, 17 cm. |
| October ... | ... | 15 cm. |
| November | ... | 14, 15, 15, 17 cm. |
| December | ... | 14, 16, 17 cm. |

No attempt has been made by means of percentages to determine the chief months when the males become mature, the reason being that owing to the handling and washing after the animals are caught such external signs as those observed would in many cases be destroyed. It is perhaps worth noting from what records have been obtained that the largest number of large males having these signs were found from July to September, three of the chief casting months for the females, and that only smaller males were found in February and April.

The smallest berried female found measured 8 cm.; one has been taken measuring 9 cm., three measuring 10 cm., and several of other sizes up to 17 cm.

Casting.—Tables VII. and VIII. show for each month the number and percentage of males and females which have been found in the samples when in a soft condition or recovering from casting. From the percentages it is clear that the chief casting month for males is April. But from information obtained from fishermen and buyers of large quantities of prawns, the males were casting during the latter part of March. For at that time, amongst baskets of large prawns, by far the greater number of which are males (see Table IV.), the buyers found many in a soft condition, and the fishermen told me of finding many large prawns which were soft. Prawns are considered to be large by the buyers and fishermen when over 15 cm., and these are roughly separated from the others before being sold.

The chief months during which the males are casting are therefore March and April.

Hardening of the shell appears to take place fairly quickly. On 30th April, 1912, a trip was taken on one of the vessels fishing for prawns. It was noticed that only one or two males were taken in a really soft condition, but many were caught with the shell quite clean, and although not so hard as in individuals which had not cast, considerable pressure had to be applied with the finger and thumb before it was possible to break the shell of the chelæ.

With the exception of January and March, females which have recently cast have been found in every month of the year, but by far the greater numbers occur from June to September, the highest percentage obtaining in July.

If the particulars relating to casting, spawning, hatching, and maturity of males be now considered together, it will be seen that that the males cast chiefly in March and April, later the young hatch, and the highest percentage of casting females shortly afterwards occurs in the months June to September. In August, the greatest number of males with external signs of maturity was obtained.

It is not suggested that these observations are complete, and by work at the Laboratory I hope to be able to give further particulars relating to spawning, hatching and the period of incubation, and also to obtain some facts relating to the life history of Nephrops.

Tides and Catches.—It is generally held amongst the fishermen that the greatest catches of Norway Lobsters are made when the tides are "easy" or neap, and the smallest catches during the "heavy" or spring tides. In order to ascertain if this was correct for a period extending over a year, the following particulars have been considered by means of statistics kindly supplied by the Board of Agriculture and Fisheries for the year 1911. The year has been divided into lunar months, commencing with the new moon; the mean landings of Norway Lobsters in cwts. for vessels absent from the port for one day have been calculated for each day of the lunar month, and a curve has been drawn. The state of the tide is shown by taking the depth of water in feet at the mouth of the Tyne during September, 1911. It is obvious that the greatest depth of water will be during the spring tides.

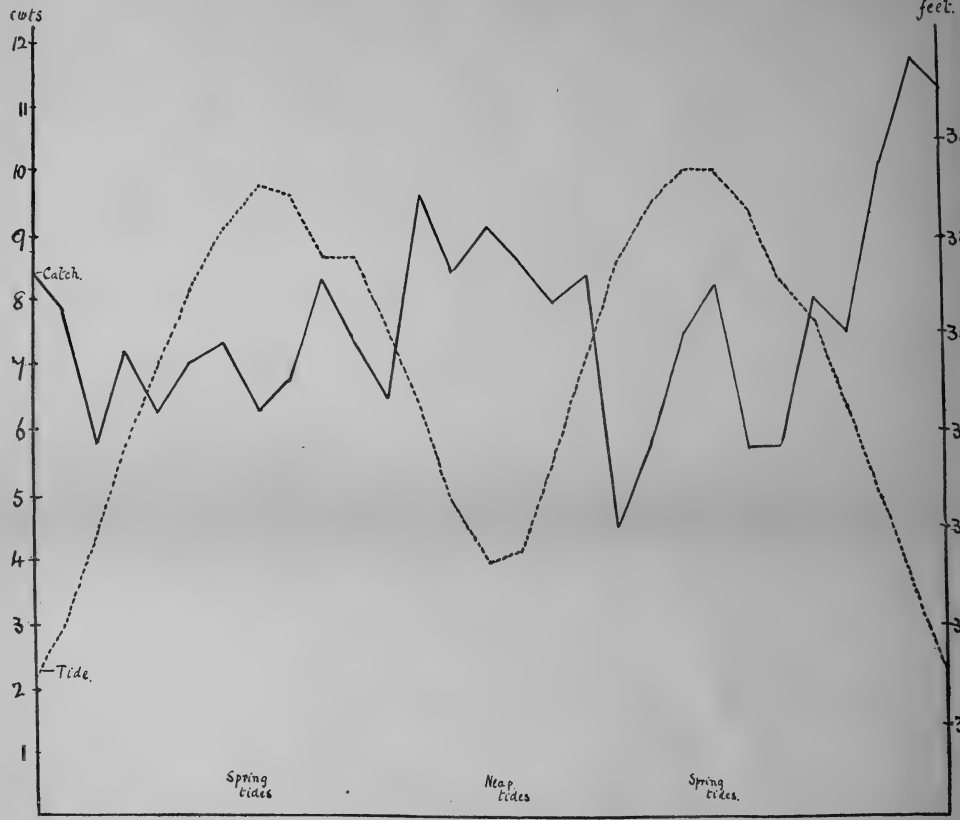
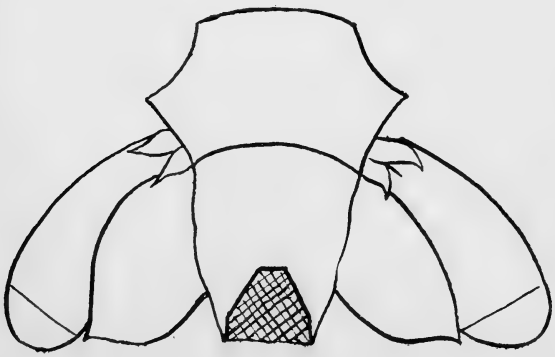



CHART I.—Norway Lobsters—Tides and Catches.

Chart I. shows the curves which have thus been obtained, and a certain amount of correlation is observable. Curves have also been drawn for each month of the year, and a similar correlation is found in the months of March, April, May, June and July, months during which it has been seen that the least quantities are caught, and also in November. In August, the catches are found to be greatest during the spring tides, and least during the neap tides. In the other months no correlation between tides and catches is to be seen. In order to obtain reliable results in this connexion more data are necessary, and statistics would be needed for a period of years before coming to any conclusion as to the relationship between tides and catches during each month of the year.

Marking Experiment.—Professor Meek suggested that some interesting facts might be obtained if a number of Norway Lobsters were marked by punching out part of the telson. In order to see if this would be detrimental to the creatures, two were punched in the telson and also in the uropods, and two months after the experiment they are still living and healthy.

On 30th April, 1912, when on board the "Raider," 365 males and 200 females were marked and liberated from 12 to 14 miles to the east of Newbiggin. Notices have been distributed amongst the fishermen and buyers at North Shields, and through the kindness of the Fishery Board for Scotland and the Board of Agriculture and Fisheries, to the fishery officers of the east coast. The telson appears as here shown.



I take this opportunity of expressing my sincere thanks to Professor Meek for his kindly advice and criticism, to Mr. Purdy for facilities granted me to conduct the observations, to Mr. Brown, skipper of the "Raider," who has saved me samples of catches and with whom I have been twice to sea, and also to Mr. Morgan, skipper of the "Ranter," with whom I went to sea during August, 1911. I am also indebted to many whom I have met at North Shields fish quay, and who have never failed to give me any information I was wanting in connexion with the Norway Lobster.

# TABLE III.

**3rd May, 1911.** **Measured at Fish Quay.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | 1 | 5 | 9 | 19 | 36 | 45 | 25 | 14 | 1 | 1 | ... | ... | 156 |
| Non-berried Females | ... | ... | ... | ... | ... | 1 | 4 | 9 | 9 | 3 | 1 | .. | 1 | ... | ... | ... | ... | ... | 28 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 |
| | | | | | | | | | | | | | | | | | | | 185 |

**12th May, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | 2 | 9 | 14 | 19 | 22 | 17 | 34 | 27 | 12 | 3 | ... | ... | 159 |
| Non-berried Females | ... | ... | ... | ... | ... | 2 | 5 | 4 | 22 | 12 | 7 | ... | ... | ... | ... | ... | ... | ... | 52 |
| Berried Females | ... | ... | ... | ... | ... | 1 | ... | ... | ... | 3 | ... | ... | ... | ... | ... | ... | ... | ... | 4 |
| | | | | | | | | | | | | | | | | | | | 215 |

**17th May, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | 3 | 1 | 8 | 8 | 15 | 10 | 7 | 16 | 17 | 24 | 5 | 2 | ... | ... | 116 |
| Non-berried Females | ... | ... | ... | ... | 2 | 7 | 12 | 12 | 13 | 2 | 1 | ... | ... | ... | ... | ... | ... | ... | 49 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | | ... | . . | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 165 |

**24th May, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | 1 | ... | ... | 3 | 10 | 4 | 23 | 25 | 22 | 27 | 18 | 7 | 5 | 1 | 1 | 147 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | 2 | 8 | 9 | 7 | 2 | 1 | ... | ... | ... | ... | ... | ... | 29 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 3 | ... | ... | ... | ... | ... | ... | ... | ... | 4 |
| | | | | | | | | | | | | | | | | | | | 180 |

TABLE III.—Continued.

**1st June, 1911.** **Measured at Fish Quay.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | 1 | 3 | 13 | 10 | 18 | 30 | 27 | 21 | 21 | 10 | 3 | ... | ... | 157 |
| Non-berried Females | ... | ... | ... | ... | ... | 1 | 5 | 4 | 4 | 4 | ... | ... | ... | ... | ... | ... | ... | ... | 18 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 |
| | | | | | | | | | | | | | | | | | | | 176 |

**30th June, 1911.** **Measured at Fish Quay. Total catch of "Raider" on previous day.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | 1 | 6 | 6 | 20 | 36 | 61 | 54 | 58 | 22 | 16 | 4 | 1 | 285 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | 2 | 3 | 1 | 1 | 1 | ... | ... | ... | ... | ... | ... | ... | 8 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | 1 |
| | | | | | | | | | | | | | | | | | | | 294 |

**11th July, 1911.** **Measured at sea on board "Raider." Catch of Nephrops for 1st haul from 10 a.m. to 2 p.m.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 4 | 9 | 8 | 16 | 9 | 15 | 3 | ... | ... | 64 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 65 |

**11th July, 1911.** **Measured at sea on board "Raider." Catch of Nephrops for 2nd haul from 2·30 p.m. to 6·45 p.m.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 | 3 | 5 | 5 | 3 | 2 | ... | ... | 20 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 20 |

TABLE III.—Continued.

**11th July, 1911.** **Measured at sea on board "Raider."**
**Catch of Nephrops for 3rd haul, 7·15 p.m. to 11·20 p.m.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | .. | ... | ... | ... | ... | 1 | 3 | 4 | 6 | 3 | 14 | 19 | 21 | 22 | 11 | 2 | ... | 106 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | ... | 2 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | .. |
| | | | | | | | | | | | | | | | | | | | 109 |

**11th-12th July, 1911.** **Measured at sea on board "Raider."**
**Catch of Nephrops for 4th haul, 11·50 p.m. to 3·40 a.m.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | 1 | ... | 1 | 6 | 2 | 11 | 19 | 42 | 49 | 36 | 30 | 13 | 3 | ... | 213 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | ... | 2 | ... | 1 | 2 | 1 | ... | ... | ... | ... | ... | ... | 6 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 219 |

**20th July, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | .. | ... | ... | ... | ... | 2 | 1 | 1 | 13 | 16 | 15 | 27 | 25 | 22 | 11 | 5 | 1 | ... | 139 |
| Non-berried Females | ... | ... | ... | ... | 1 | 1 | ... | 1 | 1 | 1 | 3 | 1 | ... | ... | ... | ... | ... | ... | 9 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 148 |

**27th July, 1911.** **Measured at Fish Quay.**
**Total catch of "Raider' for previous day.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | 1 | 1 | 4 | 11 | 40 | 61 | 82 | 129 | 131 | 102 | 51 | 19 | 2 | ... | ... | 634 |
| Non-berried Females | ... | 1 | 1 | 1 | 2 | 6 | 10 | 15 | 18 | 15 | 10 | 3 | ... | ... | ... | ... | ... | ... | 82 |
| Berried Females | ... | ... | ... | 1 | ... | ... | ... | ... | 5 | 1 | ... | ... | 1 | ... | ... | ... | ... | ... | 8 |
| | | | | | | | | | | | | | | | | | | | 724 |

TABLE III.—CONTINUED.

**2nd August, 1911.** **Measured at Fish Quay.**
**Total catch of "Raider" for previous day.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | 1 | 6 | 27 | 33 | 54 | 102 | 122 | 157 | 125 | 88 | 29 | 10 | ... | 754 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | 4 | 8 | 11 | 18 | 7 | 1 | ... | ... | ... | ... | ... | ... | 49 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 803 |

**30th August, 1911.** **Measured at sea on board "Ranter."**
**Catch of Nephrops for 1st haul, 9·45 a.m. to 1·45 p.m.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | ... | 2 | 5 | 12 | 24 | 63 | 44 | 35 | 17 | 2 | 1 | ... | 205 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | 1 | 10 | 6 | 6 | 3 | 1 | ... | ... | ... | ... | ... | ... | 27 |
| Berried Females | ... | ... | ... | ... | ... | ... | 3 | 1 | 1 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | 6 |
| | | | | | | | | | | | | | | | | | | | 238 |

**30th-31st August, 1911.** **Measured at sea on board "Ranter."**
**Sample of catch of 3rd haul (6 cwts.), 7·30 p.m. to 12·30 a.m.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | 1 | 5 | 5 | 14 | 23 | 22 | 25 | 25 | 18 | 15 | 6 | 2 | ... | ... | 161 |
| Non-berried Females | ... | ... | ... | 2 | 2 | 4 | 15 | 21 | 25 | 10 | 8 | ... | ... | ... | ... | ... | ... | ... | 87 |
| Berried Females | ... | ... | ... | ... | 1 | ... | 3 | 10 | 7 | 6 | 1 | ... | ... | ... | ... | ... | ... | ... | 28 |
| | | | | | | | | | | | | | | | | | | | 276 |

**28th September, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | .. | ... | 1 | 1 | ... | 5 | 23 | 30 | 52 | 45 | 41 | 17 | 9 | 1 | ... | ... | 225 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | 5 | 11 | 12 | 9 | 3 | 1 | 1 | ... | ... | ... | ... | ... | 42 |
| Berried Females | ... | ... | ... | ... | ... | ... | 1 | 6 | 4 | 2 | 1 | ... | ... | ... | ... | ... | ... | ... | 14 |
| | | | | | | | | | | | | | | | | | | | 281 |

TABLE III.—Continued.

**12th October, 1911.** **Measured at Fish Quay.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | ... | 4 | 8 | 11 | 20 | 11 | 24 | 19 | 8 | 4 | ... | ... | 109 |
| Non-berried Females | ... | ... | ... | ... | ... | 1 | 4 | 9 | 4 | 6 | 3 | 1 | ... | ... | ... | ... | ... | ... | 28 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | 1 | ... | 3 | 1 | ... | ... | ... | ... | ... | ... | ... | 5 |
| | | | | | | | | | | | | | | | | | | | 142 |

**19th October, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | ... | 1 | 5 | 16 | 13 | 17 | 11 | 19 | 12 | 4 | 1 | ... | ... | 99 |
| Non-berried Females | ... | ... | ... | ... | ... | 2 | 5 | 30 | 21 | 18 | 8 | 2 | ... | ... | ... | ... | ... | ... | 86 |
| Berried Females | ... | ... | ... | ... | ... | ... | 2 | ... | 4 | 2 | 1 | 2 | ... | ... | ... | ... | ... | ... | 11 |
| | | | | | | | | | | | | | | | | | | | 196 |

**20th October, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | 2 | 5 | 8 | 17 | 27 | 31 | 14 | 8 | 9 | 3 | ... | .. | ... | 124 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | 10 | 24 | 36 | 15 | 6 | 2 | ... | ... | ... | ... | ... | ... | 93 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | 3 | 8 | 3 | ... | 2 | ... | ... | ... | ... | ... | ... | 16 |
| | | | | | | | | | | | | | | | | | | | 233 |

**2nd November, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | 1 | 2 | 12 | 6 | 8 | 15 | 12 | 12 | 31 | 25 | 27 | 22 | 7 | ... | ... | ... | 180 |
| Non-berried Females | ... | 1 | 3 | 2 | 7 | 13 | 33 | 37 | 29 | 6 | 6 | 1 | ... | ... | ... | ... | ... | ... | 138 |
| Berried Females | ... | ... | ... | ... | ... | 2 | 3 | 4 | 1 | ... | 1 | ... | 1 | ... | ... | ... | ... | ... | 12 |
| | | | | | | | | | | | | | | | | | | | 330 |

TABLE III.—Continued.

**15th November, 1911.** **Measured at Fish Quay.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | 3 | 2 | 2 | 7 | 11 | 23 | 16 | 17 | 7 | 15 | 8 | 2 | ... | ... | 113 |
| Non-berried Females | ... | ... | ... | ... | 1 | 1 | 4 | 24 | 16 | 18 | 3 | ... | ... | ... | ... | ... | ... | ... | 67 |
| Berried Females | ... | ... | ... | ... | ... | ... | 1 | ... | 1 | 1 | 1 | 1 | ... | ... | ... | ... | ... | ... | 5 |
| | | | | | | | | | | | | | | | | | | | 185 |

**1st December, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | 1 | 1 | 11 | 20 | 17 | 16 | 17 | 12 | 8 | 8 | 1 | ... | ... | 112 |
| Non-berried Females | ... | ... | ... | ... | 1 | 1 | 9 | 19 | 11 | 9 | ... | ... | ... | ... | ... | ... | ... | ... | 50 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 162 |

**7th December, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | 4 | 5 | 11 | 19 | 20 | 20 | 20 | 15 | 3 | 7 | 2 | ... | ... | 126 |
| Non-berried Females | ... | ... | ... | ... | ... | 1 | 9 | 15 | 18 | 15 | 8 | ... | ... | .. | ... | ... | ... | ... | 66 |
| Berried Females | ... | ... | .. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 192 |

**13th December, 1911.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | 4 | 1 | 3 | 18 | 14 | 5 | 12 | 12 | 11 | 9 | 4 | 7 | 3 | 2 | ... | ... | 105 |
| Non-berried Females | ... | ... | 2 | 3 | 8 | 16 | 29 | 69 | 43 | 39 | 9 | 1 | ... | ... | ... | ... | ... | ... | 219 |
| Berried Females | ... | ... | ... | ... | ... | ... | 1 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 |
| | | | | | | | | | | | | | | | | | | | 326 |

TABLE III.—Continued.

**10th January, 1912.** **Measured at Fish Quay.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | 2 | 9 | 9 | 15 | 31 | 34 | 43 | 25 | 19 | 12 | 11 | 5 | 2 | ... | 217 |
| Non-berried Females | ... | ... | ... | ... | 1 | 3 | 5 | 12 | 10 | 8 | 8 | ... | ... | ... | ... | ... | ... | ... | 47 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 264 |

**24th January, 1912** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | ... | ... | 4 | ... | 4 | 9 | 12 | 19 | 9 | 22 | 11 | 12 | 4 | ... | ... | 106 |
| Non-berried Females | ... | ... | ... | ... | ... | ... | 2 | 11 | 4 | 11 | 7 | 1 | 1 | ... | ... | ... | ... | ... | 37 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | . | ... | ... | ... | ... | .. | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 143 |

**30th January, 1912.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | 1 | ... | 1 | 1 | 2 | 6 | 8 | 21 | 13 | 20 | 30 | 14 | 4 | 3 | ... | 124 |
| Non-berried Females | ... | ... | ... | 1 | 3 | ... | 4 | 7 | 7 | 5 | 4 | 1 | ... | ... | ... | ... | ... | ... | 32 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 156 |

**14th February, 1912** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | ... | 1 | 4 | 5 | 5 | 10 | 13 | 17 | 8 | 16 | 14 | 14 | 10 | 1 | 1 | ... | 119 |
| Non-berried Females | ... | ... | ... | 2 | 4 | 8 | 15 | 22 | 15 | 8 | 7 | 2 | 2 | ... | ... | ... | ... | ... | 85 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 204 |

TABLE III.—Continued.

**21st February, 1912.** **Measured at Fish Quay.**
**Half of catch of "Raider" for previous day.**

CENTIMETRES.

| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | 3 | 4 | 2 | 44 | 22 | 20 | 44 | 22 | 16 | 7 | 13 | 24 | 12 | 4 | 1 | ... | 238 |
| Non-berried Females | ... | ... | 3 | 3 | 10 | 33 | 38 | 53 | 53 | 26 | 7 | 4 | ... | ... | ... | ... | ... | ... | 230 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | .. | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 468 |

**20th April, 1912.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | ... | 2 | 1 | 14 | 34 | 20 | 7 | 13 | 19 | 19 | 19 | 18 | 14 | 4 | 4 | ... | ... | 188 |
| Non-berried Females | ... | ... | ... | 1 | 9 | 23 | 13 | 61 | 31 | 8 | ... | 1 | ... | ... | ... | ... | ... | ... | 147 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 335 |

**27th April, 1912.** **Measured at Fish Quay.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | 1 | 4 | 2 | 8 | 16 | 6 | 7 | 11 | 11 | 16 | 12 | 20 | 19 | 9 | 3 | 4 | ... | 149 |
| Non-berried Females | 1 | ... | 3 | 1 | 1 | 20 | 16 | 18 | 29 | 8 | 6 | ... | ... | ... | ... | ... | ... | .. | 103 |
| Berried Females | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| | | | | | | | | | | | | | | | | | | | 252 |

## TABLE IV.

**TOTALS.**

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males ... | ... | 1 | 14 | 14 | 54 | 162 | 140 | 273 | 467 | 593 | 835 | 859 | 884 | 728 | 402 | 165 | 52 | 7 | 5650 |
| Non-berried Females | 1 | 2 | 12 | 16 | 52 | 144 | 261 | 521 | 460 | 289 | 130 | 25 | 5 | ... | ... | ... | ... | ... | 1918 |
| Berried Females | ... | ... | ... | 1 | 1 | 3 | 14 | 26 | 34 | 26 | 6 | 5 | 2 | ... | ... | ... | ... | ... | 118 |
| | | | | | | | | | | | | | | | | | | | 7686 |

TABLE V.—Proportion of Males, Females and Berried Females.

| | Number Examined. | Males. | Total Number of Females. | Berried Females. | Percentage of Males. | Percentage of Females. | Percentage of Berried Females in Total Females. | Remarks as to Condition of Eggs. |
|---|---|---|---|---|---|---|---|---|
| January ... | 563 | 447 | 116 | 0 | 79 | 21 | 0 | ..... |
| February ... | 672 | 357 | 315 | 0 | 53 | 47 | 0 | ..... |
| March... ... | ... | ... | ... | ... | ... | ... | ... | ..... |
| April ... ... | 587 | 337 | 250 | 0 | 57 | 43 | 0 | ..... |
| May ... ... | 745 | 578 | 167 | 9 | 78 | 22 | 5 | Seven had young leaving eggs or nearly ready to do so; two had dark green eggs. |
| June ... ... | 470 | 442 | 28 | 2 | 94 | 6 | 7 | One with few ripe eggs and remains of egg cases; one with young nearly ready to hatch. |
| July ... ... | 1,285 | 1,176 | 109 | 8 | 91 | 8 | 7 | Eggs in all cases dark green. |
| August ... | 1,317 | 1,120 | 197 | 34 | 85 | 15 | 17 | Two with young leaving eggs; 32 with dark green eggs. |
| September ... | 281 | 225 | 56 | 14 | 80 | 20 | 25 | One with young leaving eggs, one with very ripe eggs, twelve with dark green eggs. |
| October ... | 571 | 332 | 239 | 32 | 58 | 42 | 13 | Eggs in most cases dark green, some with light green eggs. |
| November ... | 515 | 293 | 222 | 17 | 57 | 43 | 8 | Do. do. |
| December ... | 680 | 343 | 337 | 2 | 50 | 50 | ·6 | Two with light green eggs. |
| TOTAL ... | 7,686 | 5,650 | 2,036 | 118 | 73·5 | 26·5 | 5·8 | |

## TABLE VI.—Non-Berried Females.

| No. | Date. | Condition of Swimmerets. | Colour of Ovary. | Extent of Ovary. | Remarks. |
|---|---|---|---|---|---|
| | 1911. | | | | |
| 1 | 11th July ... | Clean | Dark green | Right lobe.—To end of second abdominal segment.<br>Left lobe.—To beginning of second abdominal segment. | Eggs in ovary varied slightly in shape and size.<br>Measurements of eggs = 1·7 × 1·18, 1·54 × 1·27, 1·5 × 1·4 mm. |
| 2 | 11th July ... | Clean | Dark green | Right lobe.—To beginning of third abdominal segment.<br>Left lobe.—To beginning of second abdominal segment. | Measurements of eggs = 1·9 × 1·17, 1·6 × 1·27, 1·54 × 1·36 mm. |
| 3 | 11th July ... | With fragments of egg capsules on setæ | Light yellow | Both lobes reaching to middle of first abdominal segment. | Examined after being preserved in formalin. |
| 4 | 11th July ... | Clean | Pink | To middle of first abdominal segment; right lobe slightly the longer. | Do. do. |
| 5 | 11th July ... | Clean | Pink | To middle of second abdominal segment. | Do. do. |
| 6 | 11th July ... | Clean | Light yellow | To anterior third of second abdominal segment. | In a soft condition; shell had been recently cast. |
| 7 | 19th July ... | Clean | Dark green | Right lobe.—To end of first abdominal segment.<br>Left lobe.—To middle of first abdominal segment. | Sperms found in spermatheca, which was filled with a clear hard jelly = spermatophores. |
| 8 | 19th July ... | Clean | Dark green | Right lobe.—To end of second abdominal segment.<br>Left lobe.—To anterior third of second abdominal segment. | Do. do. |
| 9 | 19th October ... | (?) | Light yellow | To anterior third of second abdominal segment. | Measurements of eggs in ovary—<br>·8 × ·75, ·75 × ·75, ·92 × ·75, ·92 × ·8<br>·7 × ·66, ·87 × ·83, ·87 × ·8, ·8 × ·66 mm. |

## TABLE VII.

### Males in a Soft Condition or recovering from Casting.

LENGTH IN CENTIMETRES.

| | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total. | No. of Males Examined. | Per-centage. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January ... | ... | ... | ... | ... | 1 | 2 | ... | 4 | ... | ... | ... | ... | ... | 7 | 447 | 1·6 |
| February ... | ... | ... | ... | 5 | 1 | 2 | ... | 2 | 2 | 1 | ... | ... | ... | 13 | 357 | 3·6 |
| March ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| April ... | ... | ... | 1 | 2 | 3 | 3 | 7 | 5 | 9 | 2 | 1 | ... | ... | 33 | 337 | 9·8 |
| May ... | ... | ... | ... | ... | ... | 1 | 2 | 5 | 1 | ... | ... | ... | ... | 9 | 578 | 1·5 |
| June ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 442 | ... |
| July ... | ... | ... | ... | 1 | ... | 1 | ... | ... | ... | ... | 1 | ... | ... | 3 | 1176 | ·25 |
| August ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | 1 | 1120 | ·09 |
| September ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 225 | ... |
| October ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 332 | ... |
| November ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 293 | ... |
| December ... | ... | ... | ... | 1 | 2 | 1 | 3 | ... | ... | 1 | ... | ... | ... | 8 | 343 | 2·3 |

## TABLE VIII.

### Females in a Soft Condition or recovering from Casting.

LENGTH IN CENTIMETRES.

| | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | Total. | No. of Females Examined. | Per-centage. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 116 | ... |
| February ... | ... | 1 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 | 315 | ·6 |
| March ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| April ... | ... | ... | 1 | 3 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | 5 | 250 | 2 |
| May ... | ... | ... | ... | 3 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | 4 | 167 | 2·4 |
| June ... | ... | 1 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2 | 28 | 7·1 |
| July ... | 1 | 2 | 1 | 3 | 2 | 2 | ... | ... | ... | ... | ... | ... | ... | 11 | 109 | 10·1 |
| August ... | ... | 2 | 4 | 3 | 2 | 2 | 1 | ... | ... | ... | ... | ... | ... | 14 | 197 | 7·1 |
| September ... | ... | ... | ... | 3 | 1 | ... | ... | ... | ... | ... | ... | ... | ... | 4 | 56 | 7·1 |
| October ... | 1 | ... | 2 | 4 | 2 | 1 | ... | ... | ... | ... | ... | ... | ... | 10 | 239 | 4·2 |
| November ... | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 222 | ·45 |
| December ... | ... | 1 | 2 | ... | ... | 1 | ... | ... | ... | ... | ... | ... | ... | 4 | 337 | 1·2 |

# LOBSTER CULTURE.

By A. MEEK.

The alterations last summer connected with the new storage tank interfered to some extent with the experiments, but the results are the best we have obtained so far.

The supply of berried lobsters was obtained from the local fishermen in April and May. They were placed in the small tanks of the workers' aquarium, and were afterwards transferred to the centre pool of the public aquarium. In the meantime, in accordance with our previous experience, a number of eggs had been lost. A number of berried lobsters were placed also in an open air tank on the roof of the building. The depth of the centre pool is 16 in., and of the roof tank 26 in.

The first larvae were observed in the roof tank on June 8th, and the first lobsterling was found in this tank on July 2nd. About 160 larvæ were removed from the roof tank to the small tanks in the workers' aquarium and of these 30 or 18 per cent. were reared to the lobsterling and succeeding stages. The water supplied to these tanks was filtered. On July 10th, the roof tank was cleaned, and 16 lobsterlings were found, and these with the 30 already mentioned made a total of 46. Six of these were placed in one of the large tanks of the public aquarium on July 29th. Of those remaining in the workers' aquarium, some had reached the sixth stage on August 3rd, when 24 were still living. Many died in casting, and some were found with the cuticle torn, and the under part of the thorax eaten away. The last died on September 4th, and was then 1·9 cm. long. Of those placed in the large tank, two were found to be living on September 27th, and were then about 3·5 cm. long. They were removed to a glass vessel in the workers' aquarium. One died in casting on October 8th. The other cast on March 16th, when it reached the size of 4 cm. This one is still alive (June 30th).

In the floor pool the first larvae appeared on July 2nd, and on July 12th, 160 larvæ were taken to the roof tank. Those

remaining in the floor pool gradually decreased in numbers. Towards the end of September the pool was cleaned, and no lobsterlings were found. When the roof tank was cleaned in November a young lobster was found which measured 5 cm. This one cast on May 17th, and now measures 5·5 cm.

We have thus at all events two young lobsters very nearly a year old, which have been successfully reared from the egg.

The small number of larvæ which has been obtained each year is doubtless due to the small area of the tanks in which the berried lobsters have been placed. It appears therefore that the first point of importance to be observed is the provision of a large pond for the reception of the berried lobsters and for the hatching of the larvae. The pond would have to be placed also in a position where a perfectly pure supply of sea water could be obtained. In America, Dr. Mead realised this by placing hatching boxes on rafts in the sea, and he further provided for the water in the boxes being kept in constant motion by the use of revolving propellers. With this apparatus, he has been able to rear 40 per cent. to the lobsterling stage, dealing with quantities like 20,000 larvæ in each box. On an exposed coast like ours the difficulty would be to obtain a sheltered region where the American plan could be adopted. There is a pond at Amble as I have pointed out before (Report for 1905), which could be easily cleaned and converted into a centre for lobster culture with the use of rearing ponds, or by adopting the American method. Perhaps better success would attend the establishment of a hatchery on the Farne Islands, if only on account of the absolute purity of the water. The difficulty would be to discover a place in such an exposed situation where the operations could be conducted with safety, and there is the further difficulty as to the transport of the berried lobsters to a relatively inaccessible place. Still when the matter comes to be considered, the claims of the Farne Islands must not be overlooked.

With such a pond as that indicated, a simple experiment would be well worth trying, viz., to put a number of berried lobsters into the pond and see whether it would be possible to hatch and rear a reasonable percentage to the adult stage without interference.

For the purposes of stocking the fishing grounds on the coast our experiments tend to show that the lobsterlings will do better in the open sea than if confined to small tanks or the like, that in fact the best time to liberate them is as soon after the lobsterling stage as possible.

The above young lobsters are interesting as indicating the size at about one year (see the report for 1904, p. 52). It will be seen that the growth is almost exactly the same as that of the American lobster, but the material being gathered of the various stages will be considered on another occasion.

# PROTECTION OF THE LOBSTER.

By A. MEEK.

In the Annual Report of Proceedings under Acts relating to Sea Fisheries for the year 1910, published in April, 1912, the Board of Agriculture and Fisheries give the results of the enquiry made as to the size, sex, and condition of lobsters, with a view to providing a "solid basis of fact" for the consideration of the question of further protection of lobsters. The matters discussed, and the conclusions come to are of the greatest importance to the Fishery Committees of England, and not the least to the Northumberland Committee, since the question of the protection of the lobster has been fully considered at the meetings, and has been the subject of investigations now extending over a period of more than fifteen years at the Marine Laboratory. The results of the investigations have been published in the annual reports from year to year, and in the report for 1904 were brought together in a special paper to which the Board refers, and the important conclusions have been illustrated by papers in several of the subsequent reports, the last being in the report for 1909-1910. With a view therefore to adding to the information furnished by the Board, the following analysis and criticism of the paper may be ventured upon.

A table is first given showing the catches for England and Wales for each year during the period 1900-1909. From this it appears there has been a falling off for the east and west coasts, and an increase on the south coast. This is followed by a table giving the catches for 1907-1910 for each of the Committee's districts. From these tables it is seen that the south coast is the most important, the landings being usually more than equal to the other two coasts together, and that on the east coast the most lobsters are landed in the Northumberland district.

Before leaving this consideration of the statistical value of the lobster fisheries of the various Committees, it ought to be mentioned that not very long ago the most lobsters were landed in the North Eastern district. It is important to remember also that from 1899 in Northumberland the size limit has been 9 in., and the berried lobster has been protected during the months April to July. From 1896 in the North Eastern district the size limit has also been 9 in., and there is a close time for lobsters from 1st September to 1st February. In the Eastern district and in the Kent and Essex district the size limit remains at 8 in., but the berried lobster is altogether protected. The improvement shown in the catches of the Northumberland fishermen took place after the passing of the bye-law. As has been pointed out in previous reports, it was in 1904, five years after the protection was commenced, that Northumberland advanced into the first position, and the improvement then shown has been maintained. This point will be referred to again when the conclusions of the Board are brought under review.

The statistics of the landings for each month on each of the coasts are next considered. On the east coast the catches are principally made in the months April to June. This agrees with what has been stated before for Northumberland. Here the height of the season is reached in May, and extends from March to July mainly, but as may be expected it varies with the season. On the south and west coasts the principal catches are not confined so sharply to a limited period, the season extending from April to September. The season, however, is largely determined by the incidence of other kinds of fishing, and also winter, when lobster fishing practically ceases, not, as is suggested, from the bad weather and the sluggish condition of the lobsters, but because during that period the traps are placed in deeper water where they are safer, and it is only rarely, and at great risk of loss of gear, that they are placed in situations favourable to the catching of lobsters.

From this analysis of the fishing for lobsters during the year, it is at once apparent that the close time of the North Eastern district is at the wrong period of the year, and at any rate the statistics show that it is without value.

Interesting tables are then given to indicate the proportion of lobsters under different sizes—9, 10, 11 and 12 in. The figures for the small lobsters under 9 in. are derived mainly from the Sussex returns, the size limit in that district being 8 in.—the percentage below 9 in. being found to be 23·9 of the total catch. This figure appears to be large when considered in comparison with those I obtained several years ago from Mr. J. Douglas, Beadnell. In the report for 1904 it was pointed out that the totals for the six years ending 1904 were:—

| | Hard. | | Berried. | | Small. |
|---|---|---|---|---|---|
| | 4,655 | ... | 712 | ... | 478 |
| Adding 1905 | 526 | ... | 72 | ... | 28 |
| | 5,181 | | 784 | | 506 |

The hard referred to the lobsters which were marketable, the berried and small to the lobsters which were returned to the sea. The percentage of the small lobsters under 9 in. to the total catch, including the berried lobsters and the small, is therefore 7·8, say 8, or 8·7 if the berried lobster be deducted. It appears also to be smaller in the North Eastern district than that stated for Sussex.

Percentage of Berried Females. — From the evidence obtained from Sussex, the proportion of berried lobsters to the total catch was found to be 10·48, and for the North Eastern 12·4. From the above figures referring to Beadnell on the Northumberland coast, it will be seen that berried lobsters have a percentage relationship of 12·1 to the total catch, or 13·1 if the small be deducted. At Sea Houses the returns contributed by Mr. Fawcus showed that the percentage was as large as 17, but in this case the small lobsters were not included. It should be remembered also that these figures referring to Northumberland were obtained mainly during the months January to July. There is a remarkable difference between the Sussex figures and those for the east coast with regard to the times when the berried lobster is most in evidence. It was found in Northumberland that most were caught during the months that are protected, viz., April to July. This appears to be the case likewise in the North Eastern district. In Sussex, however, fewer berried lobsters evidently are caught in June, July and August, than in the other months of the year.

Size and Maturity.—The minimum size varies from about 8 in. in the southern districts to about $9\frac{1}{2}$ in. in Northumberland. It would be desirable to get further details with regard to this point.

An analysis of the figures shows that an 8 in. size limit is of very little value anywhere, a 9 in. limit protects only a few berried lobsters on the south coast, a 10 in. limit would protect 25-35 per cent. of the berried lobsters of the south coast, and only 5 per cent. on the east coast. It may be recalled, however, that the 9 in. size limit on the Northumberland coast protects 8 per cent. as caught with the apparatus at present in use by our fishermen, and that the lobsters at their next ecdysis or casting will be mature. That is to say those approaching 8 in. will have become over 9 in., and those just under 9 in. will be over 10 in.

Frequency of Breeding.—The Board refers to Cunningham's observation and to Scott's confirmation of the same that it is possible for a lobster to come into berry again without casting. This must be looked upon as a rare and abnormal proceeding. Indeed it hardly seems credible that the spermatophores could be transferred to the spermatheca of a hard lobster. In all the numerous experiments we have made at Cullercoats, hatching has been followed by ecdysis, and if a male be present it is at this period that the spermatophores are transferred to the female. In other words the frequency of breeding in the case of the adult lobster is also the frequency of casting. As I have pointed out before ecdysis at once becomes biennial in the female when maturity is reached, and this is determined not by growth but the reproductive function. The male is not subject to this modification of the relationship of growth to ecdysis. It is plain also with regard to the female that while at the onset of maturity reproduction regulates ecdysis, the balance between growth and ecdysis is restored after a few years when two or three ecdyses have taken place. After that period ecdysis regulates spawning, that is to say, when a size is reached when it is not possible to complete sufficient growth to enable casting to take place biennially. These remarks it may be mentioned are not merely theoretical, but are based on the results of observations in the Laboratory, and on marking experiments, and are true of crabs as of lobsters.

This serves to explain the figures furnished by the Board with reference to the gradual increase in the number of females in proportion to the males to a certain size, in our case about 11 to 12 in., and the decrease thereafter. The figures gathered at Sea Houses by Mr. G. Fawcus illustrate this point for Northumberland. Up to 1904, for six years this fisherman caught above 9 in. :—

| | Males. | | Females. | | Berried Females. | | Total Females. |
|---|---|---|---|---|---|---|---|
| | 921 | ... | 848 | ... | 377 | ... | 1,225 |
| 1905 | 178 | ... | 177 | ... | 59 | ... | 236 |
| | 1,099 | | 1,025 | | 436 | | 1,461 |

This gives a proportion of 100 males to 133 females in the total catch for all sizes above 9 in.

The records obtained by the Board serve to show that the spawning and hatching seasons are not very different around our coasts. The spawning season is usually July to September, reaching a maximum about the end of August. The hatching season appears to be June to August, reaching a maximum in July. This is true also of Northumberland, but we have early and late seasons. We have had for example experience of hatching taking place as late as October, and in an early season we have found all the hatching finished early in July.

Reference is made to the fall in the catch of the berried lobsters during the winter months. This has been amply illustrated in the reports laid before the Northumberland Committee, the conclusion come to based on this and the marking experiments, being that the berried lobster usually remains inshore, while the others migrate to a greater or less extent into deeper and even into extraterritorial waters when they are liable to be caught at this season by trawlers. It is very rarely that berried lobsters are caught at this or any other period of the year by trawlers.

Interesting notes are next given with reference to the relationship of length to weight. It is calculated from the results that a 9 in. limit would result in the loss of 13 to 14 per cent. of the total value of the catch. It is stated also that if a 9 in. limit were in force and it was determined to raise the limit to 10 in. this would bring about an additional loss of about 23 per cent. of the total catch.

From these and other considerations of the relationship of value to the statistics which they have procured, the Board arrives at the following calculation which is made the basis for a plea for the enforcement of a 9 in. limit, against which we have nothing to urge since we have already in Northumberland adopted this limit. But the further statement that the berried lobster is not so well worth protecting cannot be allowed to pass without contradiction.

| Protective Measure. | Value Sacrificed. | Number Protected. | Ratio of Number to Value. |
|---|---|---|---|
| 9 in. limit ... ... | 12·5 per cent. ... | 23·9 per cent. ... | 1·91 |
| Protection of Berried Females | 12·8 ,, ... | 10·48 ,, ... | 0·82 |

It is said "From this table it would appear that the 9 in. limit protects more than double the number of lobsters with the same loss of value." It will be noticed at once that the whole point and purpose of protecting the berried lobster has either been forgotten or ignored. No one to my knowledge has ever proposed to protect the berried lobster as a lobster, the desire has been to protect her because of the crop of embryo lobsters which she is carrying. If this essential point be taken into consideration the number protected in relation to the value sacrificed assumes an altogether different aspect. The number protected is the berried lobster, and the number of the larvæ which will survive to maturity.

Perhaps it will be better to put this matter of the protection of the berried lobster into figures. According to the results obtained by the Board from Sussex, the berried lobster constitute 10·48 of the total catch. In the North Eastern district it is 12·4 of the total catch. In the case of Northumberland if we take the Beadnell figures, the percentage of berried lobsters is 12·1, but as the small lobsters are already protected up to 9 in., the percentage less the small is 13, and if the berried lobster be deducted since they are also protected practically altogether by the close time in force on the Northumberland coast, the percentage may be put at 15 of the total marketable catch at the present time.

Now in 1911 there were landed in Northumberland 50,734 lobsters, and the number of berried lobsters caught would therefore be 8,610. If only one of the larvæ survive in each case the total number protected will not be, say 8,500, but 17,000; if two survive, the number would be 25,500.

The reasons for the protection of the berried lobster have been stated and restated in the reports submitted to the Northumberland Sea Fisheries Committee. The following may now be advanced in further evidence of the good results likely to follow from protecting the berried lobster.

Taking again the North Eastern district for comparison with Northumberland. In the former the lobster is protected from 1st September to 1st February, a season which from the Board's results and our own gives practically no protection at all. In both districts the size limit has been raised to 9 inches, and in the Northumberland district the berried lobster is protected for the months when it is mainly in evidence, viz., from 1st April to 31st July. We have therefore by the incidence of these bye-laws a means of contrasting the effects of protecting the berried lobster. There is no necessity for referring to the evidence in detail. It was given in the report for 1904, and in the following reports, the last paper on the subject having been given in the report for 1909-10, p. 21. In these papers it was pointed out that five years after the passing of the bye-law, viz., in 1904, Northumberland took the first position with reference to the landing of lobsters on the east coast of England, replacing the North Eastern with its much larger sea board in this respect. Northumberland has occupied the first position since, that is during the last eight years, and the North Eastern has sunk into the third position, the Eastern having advanced into the second place. This in spite of the fact that it is more than probable that the northern portion of the North Eastern district benefits from the protection given by the Northumberland bye-law. The following figures will bring the evidence furnished in the reports for 1904, and for 1909-10 up to 1911 :—

| Year. | Eyemouth. | Northumberland. | North Eastern. | Eastern. |
|---|---|---|---|---|
| 1910 ... | ... 3,145 | ... 48,877 | ... 34,215 | ... 48,100 |
| 1911 ... | ... 3,076 | ... 50,734 | ... 41,725 | ... 45,000 |

There can be no question in the face of this evidence of the desirability of protecting the berried lobster. The contrast tends to show, moreover, that it is more important to protect the berried lobster than to raise the size limit from 8 to 9 inches.

If it be found then that the statements in the paper emanating from the Board with reference to the protection of the berried lobster are not supported by the facts, the remarks

made with reference to the stripping of the berried lobster are liable to the construction that they are unfair and prejudicial, not to say erroneous. The Board as a further argument against the protection of the berried lobster tries to throw doubt on the ability of the officers of the Committees being able to determine whether a berried lobster has been stripped. This it may be urged is not fair to the Committees which are trying to protect the berried lobster, nor is it fair to the fishermen. It might be supposed that in the Northumberland district from the fact that the season is one of a few months, the temptation to strip the berried lobster would be greater than in districts where the berried female is altogether protected, that each year in fact the habit of returning the berried lobster would have to be acquired afresh. This does not appear to be the case, and so convinced are the fishermen becoming of the value of the protection of the berried lobster that many of them to my own knowledge voluntarily return them when caught at all seasons.

The Fishery Officers of the Northumberland Committee are trained to distinguish berried lobsters which have had the ova removed, and the few lobsters they discover in this condition each year are sent to me for further examination. So far the Committee has not failed to obtain conviction except once when the defence was that the lobster was caught outside the Committee's district. I venture to state that it is possible in every case to state whether the lobster was a berried lobster, and furthermore to state whether the ova were shed naturally or forcibly removed, no matter how long the lobster may have been kept after the operation.

I quite agree with what is said of the saving which would accrue to a district if the berried females could be protected in a hatchery. It is an important question, and has been handled to some extent at the Marine Laboratory. From the figures which have been furnished above it is at once apparent that each district could if it were found practicable furnish berried lobsters for a large hatchery.

Maturity of the Male Lobsters.—Some useful notes are added with regard to the period of maturity of the male lobster. The specimens examined include lobsters sent from the Northumberland coast. The conclusion is that the male lobster reaches maturity between 8 and 9 inches, and that therefore the 9 in. limit protects some of the males on attaining maturity.

# PROTECTION OF THE CRAB.

By A. MEEK.

In previous reports the reasons for the proposal to institute a close season have been fully presented—see particularly the report for 1908-9. During the season recommended, viz., October to December, the soft crabs in our district are so numerous as to constitute 70 to 80 per cent. of the catch. They enter the crab-pots in great numbers, and therefore, in spite of every care, are liable to destruction. It is the fact also that the majority of the soft crabs during these months are females, the males casting later. It is only a small proportion of the catch which the fisherman is able to consign to market. It consists of males which are about to cast, and of females which are about to become berried. It also includes a variable number of soft or white crabs which have been overlooked. The consequence is a liability to disgust the consumer, and to have the consignment condemned, and the marketing is done in a season when the prices are at their lowest.

As I have shown in the reports referred to, an interesting comparison may be made between the North Eastern and our own district with regard to the landings of crabs for the period during which statistics are available. In both districts it may be taken for granted that the conditions are fairly parallel so far as the increase in the catching power is concerned. But from 1896 to 1906 a close time was in operation in the North Eastern district from September 1st to January 31st each year. During these years, therefore, while the Northumberland fishermen could fish at all seasons of the year, the fishermen of the North Eastern district could only fish for seven months. It is well known also that in Northumberland, during the years in question, the autumn fishing for crabs reached a high degree of intensity.

In the North Eastern district the average catch for the five years preceding the period of protection was 1,845,670 for the five years preceding the repeal of the bye-law, 2,139,444 ; and for the five years after the repeal of the bye-laws, 2,037,109. The period of protection each year was too long, but the statistics show that more crabs were landed in the North Eastern district during the time the fishermen could fish only for seven months each year, than during the years before and after the period of protection when they could fish all the year.

In Northumberland the statistics indicate a gradual decline in the catches, and for the last three years the figures have sunk below a million crabs each year, and this brings them into striking contrast with those for the preceding years.

This gives briefly the main arguments which have led the Northumberland Committee to recommend a close time for crabs from October 1st to December 31st each year. It is the season which suits at all events the conditions in Northumberland, and is plainly also the season which would yield the best results in the North Eastern district. It is more than likely that it will also be found to be the main casting season in the Eastern district.

The following figures will bring the information I have previously published with regard to the statistics up to the year 1911 :—

| | Northumberland. | North Eastern. | Eastern. | Eyemouth. |
|---|---|---|---|---|
| 1909 | ... 828,377 | ... 1,789,705 | ... 1,253,000 | ... 335,500 |
| 1910 | ... 743,306 | ... 2,054,547 | ... 1,285,000 | ... 302,500 |
| 1911 | ... 969,397 | ... 2,075,607 | ... 1,087,000 | ... 366,570 |

# SEA WAVES AND THE DESTRUCTION OF CRAB POTS.

By H. MORRIS AIREY, M.Sc.

The crab fishing industry on the Northumberland coast attracts a sufficient number of fishermen to make the conditions under which their work is carried on a matter of general interest. Not the least interesting amongst the many problems which their calling gives rise to, is the question of the frequent damage to their gear by the North Sea storms. While it is quite obvious that the heavy seas are responsible for the wholesale destruction that sometimes occurs, it is by no means clear exactly how the mischief is done. It seems therefore desirable to draw attention to some of the factors which probably are of importance.

The destroying powers of breakers on a beach are of course evident enough, but the destruction of crab pots rarely takes place through this cause. The damage is mostly done in deep water, often in a depth of 20 fathoms or more. As will be pointed out later, waves may become breakers even in such deep water but in this case it is no longer obvious that their violence extends sufficiently far down to cause damage. The motion of the under water when a wave breaks in deep water has not been investigated theoretically and little experimental data are available. It is certain however from the experiences of divers that a long wave breaking in 5 or 6 fathoms causes a downward rush of water extending to the sea floor, which is violent enough to cause considerable damage to structures much less fragile than a crab pot. There is reason for thinking that this downward current extends to the bottom in still deeper water, but only in exceptional cases would this compare with the under water motion which accompanies all unbroken waves. It is the latter motion which will be considered in the following.

The life of a wave may be divided into three stages. During the first, it is generated by the action of wind at some distant place, and in the case of a swell it forms one of a regular series which travel from the deep water towards the shore. In its second stage it has arrived in shoaling water and the sea bottom begins to have an influence on its shape and speed. The effect of the land is to retard the wave and alter the wave length (the wave length is the distance from crest to crest between two consecutive waves of the same series). As the velocity diminishes, the wave length shortens in such a manner that the period remains unchanged. The period is the number of seconds taken by the wave to travel its own length.

It follows therefore that the time between the passage of two consecutive waves of a series across any fixed point of observation is the same wherever the point may be chosen, in deep water or near the beach. This is a most useful property as it enables us to learn much about the behaviour of the waves at some distance from the land by merely observing the number of waves which reach the shore in a given time. It can be shewn that the wave length in feet is equal to the square of the period in seconds multiplied by $5\frac{1}{8}$ for a wave in deep water, hence the importance of being able to measure the period conveniently. The change in wave length experienced in the second stage leads to an increase in the height of the wave and finally when the increase in height has caused the angle at the crest as seen in profile, to become less than 120 degrees the third stage is reached when the wave becomes a breaker and the water at the crest is thrown violently forward.

The particles of water in the surface of a wave are found to be moving in vertical circles whose diameter is determined by the height of the wave, and as each particle is in a slightly more or less advanced stage of its revolution than its neighbours in the direction of motion of the wave we get the characteristic trochoidal outline of a wave seen in profile. The particles just below the surface are revolving in circles of slightly less diameter and so on as we go downwards. The ratio in which the motion decreases depends on the wave length of the wave. The diameter of the circle of motion becomes halved for a depth equal to one ninth of the wave length and at a depth equal to the wave length, the diameter is only one five hundredth of that at the surface.

These figures refer to waves in deep water and when the wave reaches shoaling water the numbers have to be modified. The motion of the particles is also distorted and instead of circles we find the particles near the bottom moving in ellipses. The action of a wave on the water at the bottom is now such that the particles after rising slightly are carried forward nearly horizontally returning to their original position by a nearly horizontal motion at a lower level. The ratio of the horizontal motion at the bottom to that at the surface depends on the depth of water relative to the wave length and this relation is shown in the Table.

It will be clear that it is a matter of great importance to be able to determine the wave length at various times of the year, if we are to learn anything of the conditions under which the crab pots are exposed. During the past year I have been able to get an automatic record of the period of the North Sea waves by means of an apparatus placed in the lighthouse of the South Shields pier by the kind permission of the Tyne Improvement Commissioners. It has been possible also to obtain a rough estimate of the height of the waves. These records show that the periods vary from 3 seconds to 12 seconds although the latter value occurs but rarely. During the winter months the average period is 5 to 6 seconds, which corresponds to a wave length of about 156 feet in the open sea. The average depth of crab pots would be about 21 fathoms, and on reaching this depth the waves would have a length of roughly 150 feet, and a velocity of about 30 feet per second. The maximum velocity of the water particles at the surface is therefore also 30 feet per second, which gives for the horizontal velocity at the bottom only 4 inches per second. But with a long period wave having a wave length of say, 500 feet, the velocity at the bottom would be one half of that at the surface and there is little difficulty in accounting for the damage done to crab pots by waves if they are accompanied by motions of the water on this scale.

The elliptical motion of the water plays an important part in the transport of shingle and sand. A body which settles down moderately slowly in water will have a good chance of being transported rapidly. A body which allowed itself to be carried forward by the water, but anchored itself when the back flow

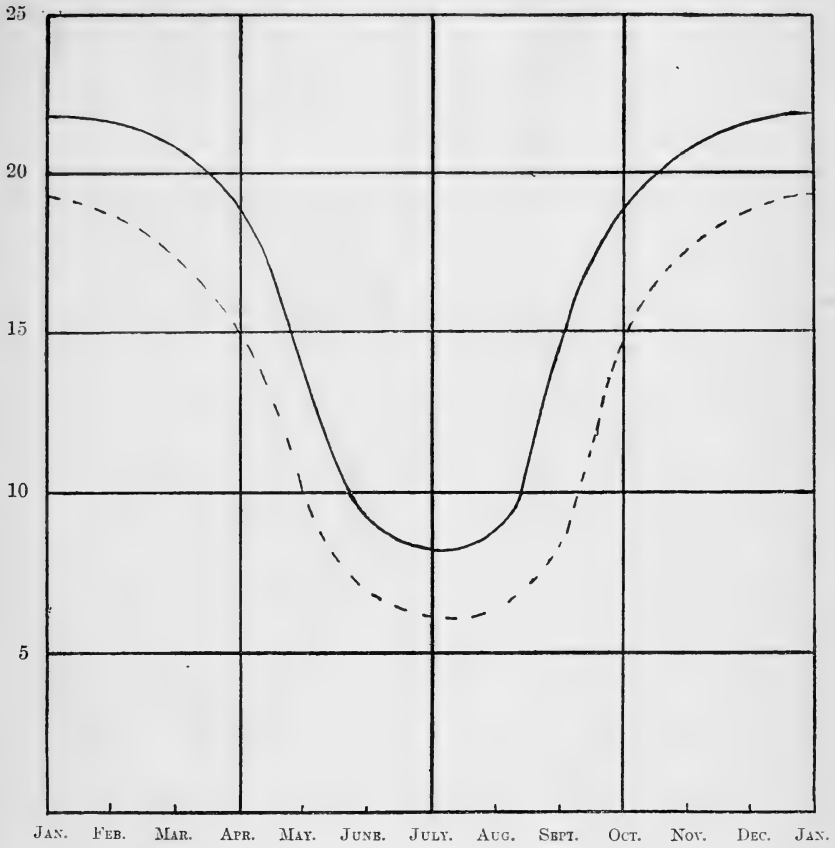
took place would be able to travel quickly and with little effort. How far this is made use of by living creatures is I believe, not known.

The depth at which crab pots are placed varies with the seasons, and it is a matter of some interest to see how the average movements of the water at the sea bottom varies throughout the year. I find for the past year, the curve showing the depth at which the velocity at the bottom was one foot per second is practically parallel to the curve showing the depths at which it is the common practice to place the pots. These latter depths have of course been found by experience to represent the depths at which the crabs are caught best, and it would seem that there is a connection, indirect or direct, between the migration of the crabs and the maximum flow of water on the sea bottom.

The depths at which crab pots are employed should afford protection at all seasons of the year for the case of waves of normal period, even if these waves become fully developed and break. In the case of sudden squalls, although the period at the commencement is much less than the normal period, this rapidly increases and the waves attain their most dangerous length and height some hours after the commencement. In many cases that have been automatically recorded the most dangerous period has occurred after 18 or 24 hours.

TABLE IX.

| Depth of Water. | Horizontal Motion at Bottom. |
|---|---|
| Wave Length. | Horizontal Motion at Surface. |
| ·01 | ·998 |
| ·02 | ·992 |
| ·04 | ·969 |
| ·06 | ·933 |
| ·08 | ·886 |
| ·1 | ·831 |
| ·2 | ·527 |
| ·4 | ·161 |
| ·6 | ·046 |
| ·8 | ·007 |
| 1·0 | ·004 |




The curve shown in full represents the relation between the depth of water in which the crab pots are placed and the month of the year. The curve shows the average of numbers supplied by fishermen from all the important fishing centres of the Northumberland coast.

The curve drawn dotted shows the depth of water where the velocity at the bottom is approximately one foot per second. In constructing this curve, the automatic records have been made use of, an average being taken of the wave periods and also of the wave heights. In doing this, all "disturbed" days have been neglected. It must be remembered that these records extend over one year only.

# MUSSEL CULTURE.

By A. MEEK.

It is still the fact that the fishermen obtain their supplies of mussel bait from Morecambe Bay, and this is as true of Sea Houses as it is of Cullercoats. I have not yet had an opportunity of consulting Mr. Dawson as to his success since he took over the Budle Bay Mussel beds.* But the experiment which has been made on Fenham Flats shows that far more mussels than would be required in the district could be grown on the scaup there. The experimental series of beds were left without attention for about a year, and suffered to some extent. I have had placed on a fresh portion of the scaup a quantity of young mussels removed from the Snook at Holy Island. The result of this experiment will be communicated later.

There was a small bed of young mussels on the scaup which had naturally formed there. The mussels have been removed by some of the Holy Island fishermen to form small scaups for their own use. I shall also attempt to find out how these small beds progress.

The experiments which have been made leave no doubt in my own mind as to the success which would attend the formation of a large mussel farm on the area known as the Scaup. As I have stated before there is already a plentiful supply of mussels which have naturally spatted, and these could be utilized to start operations. Spatting occurs naturally at various places on the flats and in the neighbourhood, and a constant supply would thus be obtained, a supply which would be increased if the scaup were covered with mussels.

* Mr. Dawson has written to me with regard to the Mussels at Budle Bay. He has had some cultural difficulties, but he complains more about the fishermen continuing to buy mussels from a distance rather than from Budle. I shall take an early opportunity of visiting the beds in Mr. Dawson's company.

The only question that remains to be settled is who is to undertake the development of the region, on the lines which could be laid down? If a large supply of mussels could be got from Fenham Flats it would be of great benefit to local fishermen. It would encourage line fishing in the district. The working of the beds would bring about a welcome new industry to many of the men and women at Holy Island. For these and other reasons I should be glad to give any information and help with a view to getting a mussel farm established.

# TRAWL-CAUGHT HERRING LANDED AT NORTH SHIELDS.

By A. MEEK and B. STORROW.

Large quantities of herrings caught by local trawlers were landed at North Shields during the months September and October of 1911. The fish were first obtained on the 26th of August, and by the 16th of October some 680 tons had been landed, some of the boats having extremely large catches. On the 26th of October the skipper of the "Wild Rose" said that the herrings were becoming thinner in number, and were scarcely worth going after. In November small quantities were caught, the last lot of which there is any record being on the 15th, when 20 baskets each containing about 150 fish, and caught 135 miles E.N.E. of the Tyne, were landed by the "Wild Rose," the skipper informing us that they had been catching from one to two baskets each drag.

The fish when landed were in good condition, the larger individuals were mature, and almost ready for spawning, and save for the loss of scales were equal in quality to drift-net herring. In the latter part of October and in November the quality was not so good, as many "spents" were taken, and most of the remainder were too small for curing. These herrings then were gathered together for the purpose of spawning, and differ from those caught off the Northumberland coast during the summer months in having a later spawning season.

The area fished during the period when the largest catches were made was situated 120 miles E. of the Tyne and extended about 25 miles to the N.E. and S.W. of this position. Towards the latter part of October the fishing was chiefly in the southern portion of this area.

For a short time in the middle of October, and in the same area as the herrings were found, large quantities of mackerel were caught, one vessel taking as many as 250 large baskets in one haul of two hours duration. The contents of the stomachs of ten of these mackerel were examined and were found to consist of the scales of some young fish.

During the period these herrings were being caught by local trawlers, a number was examined. Measurements were made, and sex, condition of gonads, and number of winter rings shown by the scales determined. These particulars will be found in Table I.

The measurements made were as follows: total length of the fish, length of scale-covered portion, that is from the edge of the operculum to the beginning of the middle of the tail, length of head from snout to operculum, length from snout to ventral fins, anal fin, beginning of dorsal fin and end of dorsal fin respectively.

The state of the gonads is indicated in the same manner as by Hjort.*

1. Virgins. Gonads small, eggs invisible to the naked eye.
2. Gonads longer than half the body cavity, and about 1 cm. in diameter. Maturing virgins or recovering spents.
3. Gonads more swollen and filling more than half the body cavity.
4. Gonads filling nearly two-thirds of the body cavity.
5. Gonads filling body cavity. Ovaries with large transparent eggs. Milt white.
6. Roe and milt running.
7. Spents.

No record was kept as to the amount of fat present in the body cavity, but the general impression obtained was that in the case of maturing individuals the quantity of fat decreased with the increase in bulk of the gonads

Altogether 101 herrings have been thus examined, and this number is made up of samples taken on the 17th, 19th and the 26th of October. The last sample purposely contained many small as it was desired to obtain measurements of other than large fish. The measurements made are summarised in Table II where the mean total length for each centimetre group is taken as 100, and the mean lengths for the other measurements are expressed as percentages of the total length. On 28th Sept. some 15 herrings were examined as to the state of the gonads, and none was found to be spent.

*Pub. de Circonstance No. 53, p. 35.

Although the number examined is few yet it is evident that the length of the scale-covered portion is greater and that of the head smaller in proportion in the larger than in the smaller herrings. It is perhaps worth noting how small the difference is between the length of the scale-covered portion and the distance from the snout to the anal fin. In Table I will be found several cases in which these measurements are the same.

A great deal of variation is found between the size and the number of winter rings, which according to Dahl* indicate the age of the herring. For example, in the samples examined it was found that the herrings from 27 to 28 cm. long might show on the scales from 4 to 11 winter rings. Yet from these observations the herring becomes mature after the formation of the third winter ring, but may do so before its formation. Figures 1 and 2 show typical scales of 5 and 8 winter rings from these herrings. Growth would seem to be rapid up to the formation of the third winter ring, less rapid between the third and the fourth, with a slowing down afterwards.

The contents of the stomachs of several of the herrings landed on the 26th of October were examined, but owing to the time taken in reaching North Shields after leaving the fishing ground, these were as a rule too much decomposed to allow of satisfactory investigation. What material was obtained consisted chiefly of fragments of crustaceans with very few whole animals.

The following have been identified from whole specimens.

Larval Decapods :
Megalopa (fragments).
Metazoëa (*Pagurus bernhardus* ?)

Copepods : *Calanus helgolandicus.*
*Pseudocalanus elongatus.*
*Temora longicornis.*
*Centropages typicus.*
*Harpacticus chelifer.*

*Euthemisto compressa* (small variety).

*Ceratium tripos.*

Copepods were found in large quantities, the two chief being *Calanus helgolandicus* and *Temora longicornis. Ceratium tripos* was present in fair numbers. The other fish caught by the trawl when fishing for herring were chiefly haddocks and whiting with a small number of gurnards and skate.

*The Scales of the Herring. Rep. Norw. Fish. Vol. 2, No. 6.

By the kindness of Mr. J. J. Kirkwood 30 herrings which had been sent from Yarmouth were examined on the 14th of November at the curing house of Messrs. Woodger & Son. The measurements made are given in Table III, and show practically no difference between these and the trawl-caught herrings.

The scales were of two types. Figure 3 shows what may be called the typical scale of this sample, having a growth similar to that of the trawl-caught herring (figs. 1 and 2). In fig. 4 the growth preceding the formation of the first winter ring is small and is followed by a large growth between the first and second winter rings. This type of scale was found in Nos. 1, 3, 13, 24, 25 and 26.

To Mr. Purdy we are indebted for particulars relating to the fishing ground and the quantities caught.

# TABLE I.

## TRAWL-CAUGHT HERRINGS LANDED AT NORTH SHIELDS.

| Number. | Total Length. | Length of scale-covered portion. | Length of head. | To ventral fin. | To anal fin. | To beginning of dorsal fin. | To end of dorsal fin. | Sex. | State of sexual organs. | Number of winter rings. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30·5 | 21·2 | 5·6 | 14·7 | 21 | 13·5 | 16·5 | f | 5 | 11 |
| 2 | 30 | 20 | 5·7 | 14·3 | 19·8 | 13 | 16·3 | m | 7 | 11 |
| 3 | 29·5 | 20 | 5·6 | 14 | 20 | 12·8 | 15·7 | m | 7 | 12 |
| 4 | 29·5 | 20 | 5·7 | 14·5 | 20·3 | 14 | 16·5 | f | 7 | 11 |
| 5 | 29·5 | 20 | 5·5 | 14 | 19·5 | 13·5 | 16·2 | m | 7 | 8 |
| 6 | 29·5 | 20 | 5·5 | 14·5 | 20 | 13·3 | 16·3 | f | 6 | 6 |
| 7 | 29 | 19·8 | 5·5 | 14 | 19·3 | 12·5 | 15·5 | m | 5 | 12 |
| 8 | 29 | 20 | 5·5 | 14·5 | 19·7 | 13·5 | 16·5 | f | 7 | 11 |
| 9 | 29 | 20 | 5·6 | 14 | 20 | 12·5 | 15·5 | f | 7 | 8 |
| 10 | 28·5 | 19·2 | 5·5 | 13·5 | 19 | 12·5 | 15·5 | m | 7 | 8 |
| 11 | 28·3 | 19 | 5·3 | 13·5 | 19 | 12·8 | 15·5 | m | 7 | 8 |
| 12 | 28·3 | 19 | 5·5 | 14 | 19·5 | 12·5 | 15·5 | m | 7 | 8 |
| 13 | 28 | 19 | 5·1 | 13 | 19 | 12·5 | 15·5 | f | 5 | 8 |
| 14 | 28 | 19 | 5·2 | 13·5 | 19 | 12·3 | 15·2 | f | 7 | 7 |
| 15 | 28 | 19·5 | 5·3 | 13·5 | 19 | 12·7 | 15·3 | m | 7 | 6 |
| 16 | 27·8 | 18·7 | 5·3 | 13 | 18 | 12·1 | 14·9 | f | 7 | 5 |
| 17 | 27·5 | 18·5 | 5·5 | 13·3 | 18·5 | 12·2 | 15 | f | 5 | 11 |
| 18 | 27·5 | 19 | 5·3 | 13·5 | 18·7 | 12·3 | 15·5 | m | 5 | 8 |
| 19 | 27·2 | 19 | 5·2 | 13·5 | 18·7 | 12·3 | 15·4 | m | 5 | 8 |
| 20 | 27·2 | 18·7 | 5·2 | 13 | 18·2 | 12 | 15 | m | 5 | 7 |
| 21 | 27·2 | 19 | 5·3 | 12·8 | 18·5 | 12 | 15 | m | 7 | 7 |
| 22 | 27·2 | 19 | 5·2 | 13 | 18·5 | 12·2 | 15 | f | 7 | 5 |
| 23 | 27 | 18·5 | 5 | 12·5 | 18 | 12·2 | 15 | m | 5 | 6 |
| 24 | 27 | 19 | 5·1 | 13 | 18·5 | 12 | 15 | f | 5 | 6 |
| 25 | 27 | 18·5 | 5 | 12·5 | 18 | 12 | 15 | f | 7 | 5 |
| 26 | 27 | 18·5 | 5 | 13 | 18 | 12 | 15 | f | 5 | 5 |
| 27 | 27 | 18 | 5 | 12·5 | 17·5 | 11·5 | 14·5 | f | 7 | 5 |
| 28 | 27 | 18·5 | 5 | 12·8 | 18 | 12 | 14·8 | m | 7 | 4 |
| 29 | 26·5 | 18 | 5·2 | 12·7 | 18 | 11·5 | 14·2 | f | 5 | 8 |
| 30 | 26·5 | 18 | 5 | 12·5 | 18 | 11·7 | 14·5 | m | 7 | 7 |
| 31 | 26·5 | 18 | 5 | 12·5 | 18 | 11·5 | 14·2 | m | 5 | 5 |
| 32 | 26·5 | 18 | 5 | 13 | 18 | 12 | 14·8 | m | 7 | 5 |
| 33 | 26·2 | 17·5 | 5 | 12·2 | 17·3 | 11·7 | 14·3 | m | 5 | 4 |
| 34 | 26·2 | 18 | 5 | 12·5 | 17·5 | 11·5 | 14·3 | f | 7 | 4 |
| 35 | 26 | 18·2 | 4·8 | 12·2 | 17·2 | 11·2 | 14 | m | 7 | 5 |
| 36 | 26 | 18 | 4·7 | 12 | 17·3 | 11·2 | 13·7 | f | 5 | 4 |
| 37 | 26 | 17·5 | 5 | 12 | 17 | 11·5 | 14 | m | 7 | 4 |
| 38 | 26 | 18 | 4·7 | 12·2 | 17·6 | 11·8 | 14·3 | f | 7 | 4 |
| 39 | 25·9 | 17·6 | 5 | 12·5 | 17·3 | 12 | 14·5 | m | 4-5 | 3 |
| 40 | 25·5 | 18·5 | 4·7 | 12·7 | 18 | 11·5 | 14·3 | m | 5 | 4 |
| 41 | 25·5 | 17·5 | 4·7 | 12·5 | 17 | 11·8 | 14·3 | m | 7 | 5 |
| 42 | 25 | 17·3 | 4·5 | 12 | 16·7 | 11 | 13·5 | f | 7 | 4 |
| 43 | 25 | 16·5 | 5 | 12 | 16·5 | 11 | 13·5 | m | 7 | 3 |
| 44 | 25 | 17·3 | 4·7 | 12 | 17 | 11·3 | 14 | m | 7-2 | 3 |
| 45 | 24·7 | 17 | 4·5 | 12 | 16·5 | 11 | 13·5 | m | 5 | 3 |
| 46 | 24·5 | 16·8 | 4·5 | 11·5 | 16·3 | 10·5 | 13·2 | f | 4-5 | 3 |
| 47 | 24·2 | 16·5 | 4·7 | 11·5 | 16·5 | 10·7 | 13 | f | 4-5 | 4 |
| 48 | 24 | 16 | 4·6 | 11·2 | 15·8 | 10 | 12·8 | f | 7 | 3 |
| 49 | 24 | 16·3 | 4·8 | 11·5 | 16·2 | 10·5 | 13 | f | 7 | 3 |
| 50 | 24 | 16 | 4·6 | 11·5 | 15·7 | 10·5 | 13 | m | 2 | 2 |

TABLE I.—*continued.*

| ber. | Total Length. | Length of scale-covered portion. | Length of head. | To ventral fin. | To anal fin. | To beginning of dorsal fin. | To end of dorsal fin. | Sex. | State of sexual organs. | Number of winter rings. |
|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 23·5 | 16·5 | 4 | 11 | 16 | 10 | 12·5 | m | 5 | 3 |
| 52 | 23·5 | 16·5 | 4·2 | 11·2 | 15·8 | 10·5 | 13 | m | 5 | 3 |
| 53 | 23·5 | 16 | 4·6 | 11 | 16 | 10·3 | 12·7 | m | 4-5 | 3 |
| 54 | 23·5 | 15·7 | 4·5 | 11·3 | 15·5 | 10·3 | 12·5 | f | 1 2 | 2 |
| 55 | 23·3 | 16 | 4·5 | 11 | 15·5 | 10·3 | 12·5 | m | 5 | 3 |
| 56 | 23·3 | 16 | 4·3 | 11 | 15·8 | 10·2 | 12·7 | f | 4 | 3 |
| 57 | 23·3 | 16·2 | 4·3 | 11 | 15·5 | 10·2 | 12·5 | f | 5 | 3 |
| 58 | 23 | 15·5 | 4·5 | 10·8 | 15·4 | 10 | 12·5 | m | 7 | 3 |
| 59 | 23 | 15·7 | 4·4 | 10·5 | 15 | 9·8 | 12 | f | 5 | 3 |
| 60 | 23 | 15·5 | 4·3 | 10·7 | 15·3 | 10 | 12·3 | m | 7-2 | 3 |
| 61 | 23 | 15·5 | 4·3 | 11 | 15·5 | 10 | 12·5 | f | 4-5 | 2 |
| 62 | 23 | 15·2 | 4·5 | 10·7 | 15 | 10·2 | 12·7 | m | 4-5 | 2 |
| 63 | 23 | 15·5 | 4·5 | 11 | 15·3 | 10 | 12·5 | f | 1 | 2 |
| 64 | 22·7 | 15 5 | 4·3 | 10·5 | 15 | 10 | 12·3 | m | 7 | 3 |
| 65 | 22·5 | 15·3 | 4·3 | 10·5 | 15 | 10 | 12·5 | m | 5 | 3 |
| 66 | 22·5 | 15·5 | 4·5 | 11 | 15·2 | 10 | 12·5 | m | 5 | 3 |
| 67 | 22·5 | 15·5 | 4·2 | 10·5 | 15 | 9·8 | 12 | f | 3 | 2 |
| 68 | 22·5 | 14·8 | 4·5 | 10·8 | 15 | 10 | 12·3 | f | 4-5 | 2 |
| 69 | 22·5 | 15·5 | 4·5 | 10·5 | 15·2 | 9·5 | 11·8 | m | 4-5 | 2 |
| 70 | 22·5 | 15 | 4·5 | 10·5 | 15 | 9·8 | 12 | m | 1 | 2 |
| 71 | 22·5 | 15 | 4·3 | 10·8 | 15·5 | 10 | 12·4 | m | 4-5 | 2 |
| 72 | 22·5 | 15 | 4·2 | 10·5 | 14·7 | 10 | 12·4 | m | 7-2 | 2 |
| 73 | 22·5 | 15 | 4·2 | 10·7 | 15·2 | 10 | 12·3 | f | 7-2 | 2 |
| 74 | 22·3 | 15 | 4·3 | 10·7 | 15 | 9·7 | 12·2 | f | 3 | 2 |
| 75 | 22·3 | 15·3 | 4·4 | 10·5 | 15 | 10 | 12·3 | f | 2 | 2 |
| 76 | 22 | 14·7 | 4·3 | 10·7 | 14·6 | 9·5 | 12 | m | 5 | 3 |
| 77 | 22 | 15 | 4 | 10·5 | 15 | 9·7 | 12 | m | 4 | 2 |
| 78 | 22 | 14·6 | 4·3 | 10·5 | 14·5 | 9·8 | 12 | f | 2 | 2 |
| 79 | 22 | 15 | 4·2 | 10·3 | 14·5 | 10 | 12·2 | m | 4-5 | 2 |
| 80 | 22 | 14·8 | 4·1 | 10·2 | 14·6 | 9·5 | 11·7 | f | 1 | 2 |
| 81 | 22 | 15 | 4·3 | 10 | 14·7 | 9·7 | 12 | f | 1 | 2 |
| 82 | 22 | 15 | 4·2 | 10·5 | 14·8 | 9·7 | 12 | f | 4 | 2 |
| 83 | 22 | 15 | 4·3 | 10·5 | 14·5 | 9·7 | 12 | m | 7-2 | 2 |
| 84 | 22 | 15 | 4·3 | 10·4 | 14·8 | 10 | 12·3 | m | 7-2 | 2 |
| 85 | 22 | 14·8 | 4·2 | 10 | 14·5 | 9·5 | 12 | m | 5 | 2 |
| 86 | 21·5 | 14·7 | 4·2 | 10 | 14·3 | 9·5 | 11·8 | m | 2 | 2 |
| 87 | 21·5 | 14·5 | 4 | 10·3 | 14·2 | 9·5 | 10·8 | f | 1 | 2 |
| 88 | 21·5 | 14·7 | 4·2 | 10 | 14·5 | 9·5 | 11·7 | f | 1 | 2 |
| 89 | 21·5 | 14·5 | 4 | 10·2 | 14·2 | 9·5 | 11·5 | f | 1 | 2 |
| 90 | 21 | 14·5 | 4 | 10 | 14 | 9 | 11·5 | f | 1-2 | 2 |
| 91 | 21 | 14·5 | 4·3 | 10 | 14·3 | 9·5 | 11·8 | f | 2 | 2 |
| 92 | 21 | 14·5 | 4 | 10 | 14·3 | 9·5 | 11·7 | m | 4-5 | 2 |
| 93 | 21 | 14 | 4·2 | 10 | 14 | 9·2 | 11·4 | m | 1 | 2 |
| 94 | 21 | 14 | 4 | 10 | 14 | 9·2 | 11·4 | f | 1 | 2 |
| 95 | 21 | 14 | 4·3 | 10 | 14 | 9·2 | 11·3 | f | 5 | 3 |
| 96 | 21 | 14·2 | 4·5 | 10 | 14·3 | 9·4 | 11·5 | f | 5 | 3 |
| 97 | 20·7 | 14·2 | 4 | 9·8 | 13·7 | 9 | 11 | f | 1 | 2 |
| 98 | 20·5 | 13·5 | 4 | 9·5 | 13·3 | 9 | 11 | m | 2 | 2 |
| 99 | 19 | 12·6 | 4 | 9 | 12·7 | 8·6 | 10·6 | m | 2 | 2 |
| 100 | 19 | 12·5 | 4 | 9 | 12·7 | 8 | 10·2 | f | 1 | 2 |
| 101 | 19 | 13 | 3·7 | 9 | 12·3 | 8·5 | 10·3 | m | 2 | 1 |

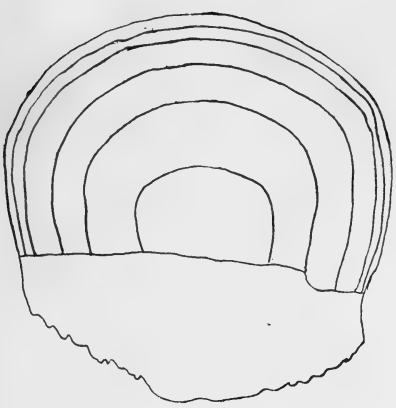
## TABLE II.

| Length in Centimetres. | Total Length. | Length of scale-covered portion. | Length of head. | To ventral fin. | To anal fin. | To beginning of dorsal fin. | To end of dorsal fin. | Number examined. |
|---|---|---|---|---|---|---|---|---|
| 30·25 | 100 | 68·1 | 18·7 | 47·9 | 67·4 | 43·8 | 54·2 | 2 |
| 29·3 | 100 | 68·27 | 18·9 | 48·46 | 67·6 | 45·05 | 54·7 | 7 |
| 28·2 | 100 | 67·7 | 18·8 | 47·8 | 67·7 | 44·5 | 54·25 | 6 |
| 27·16 | 100 | 69·2 | 18·8 | 47·86 | 67·0 | 44·4 | 55·2 | 13 |
| 26·24 | 100 | 68·2 | 18·8 | 47·25 | 67·1 | 44·05 | 54·2 | 10 |
| 25·3 | 100 | 69·0 | 18·8 | 48·6 | 67·6 | 45·0 | 55·3 | 6 |
| 24·2 | 100 | 67·7 | 19·0 | 47·5 | 66·9 | 43·4 | 54·1 | 6 |
| 23·2 | 100 | 68·1 | 18·96 | 46·98 | 66·8 | 43·2 | 53·5 | 13 |
| 22·26 | 100 | 67·6 | 19·3 | 47·17 | 66·9 | 44·0 | 54·6 | 22 |
| 21·2 | 100 | 67·9 | 19·8 | 47·4 | 66·0 | 44·3 | 54·2 | 11 |
| 20·6 | 100 | 67·0 | 19·8 | 46·6 | 65·5 | 43·7 | 53·4 | 2 |
| 19·0 | 100 | 66·8 | 20·5 | 47·4 | 66·3 | 44·2 | 54·7 | 3 |

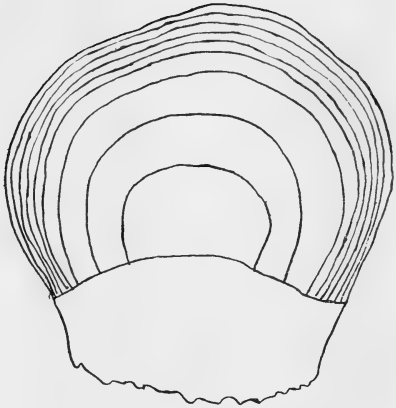
# YARMOUTH HERRINGS EXAMINED 14TH NOVEMBER, 1911.

## TABLE III.

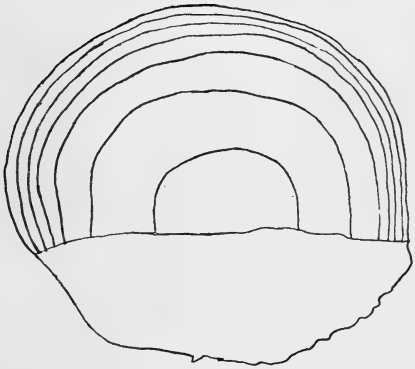
| Number. | Total Length. | Length of scale-covered portion. | Length of head. | To ventral fin. | To anal fin. | To beginning of dorsal fin. | To end of dorsal fin. | Sex. | State of sexual organs. | Number of winter rings. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 32 | 22 | 6 | 15 | 21 | 14 | 17 | f | 6 | 6 |
| 2 | 30·5 | 20·5 | 5·6 | 14 | 20·3 | 13·2 | 16·2 | m | 5 | 9 |
| 3 | 30 | 21 | 5·6 | 14·5 | 20 | 13·3 | 16 | f | 5 | 9 |
| 4 | 29·5 | 20·5 | 5·5 | 13·8 | 19·5 | 13 | 16·2 | m | 5 | 8 |
| 5 | 29·5 | 20 | 5·7 | 13·5 | 20 | 13·2 | 16·2 | f | 5 | 9 |
| 6 | 29 | 20·3 | 5·3 | 14 | 19·5 | 13 | 16 | f | 5 | 8 |
| 7 | 28·5 | 20 | 5·3 | 13·5 | 19·5 | 13 | 15·7 | m | 5 | 8 |
| 8 | 28·3 | 19·5 | 5·4 | 13·5 | 19·2 | 12·5 | 15·5 | f | 5 | 11 |
| 9 | 28 | 19·5 | 5·4 | 13 | 19 | 12·5 | 15·3 | m | 5 | 6 |
| 10 | 28 | 19·5 | 5·5 | 13·5 | 19·2 | 12·8 | 15·5 | f | 5 | 6 |
| 11 | 28 | 19·5 | 5·5 | 13·3 | 19 | 12·5 | 15·6 | m | 5 | 9 |
| 12 | 28 | 19·5 | 5·3 | 13 | 18·5 | 12·2 | 15·2 | f | 6 | 8 |
| 13 | 28 | 19 | 5·4 | 13·5 | 19 | 12·5 | 15·2 | f | 5 | 12 |
| 14 | 27·5 | 19 | 5·4 | 13 | 18 | 11·8 | 14·8 | f | 5 | 6 |
| 15 | 27 | 18·5 | 5·4 | 13 | 18·5 | 11·8 | 14·3 | m | 6 | 6 |
| 16 | 27 | 19 | 5·3 | 12·7 | 18·2 | 12 | 14·7 | m | 5 | 6 |
| 17 | 27 | 19 | 5·2 | 12·5 | 18 | 12 | 14·5 | m | 6 | 6 |
| 18 | 27 | 18·5 | 5·2 | 13 | 18·3 | 12·2 | 15 | f | 5 | 5 |
| 19 | 26·3 | 18·5 | 5 | 12 | 17·8 | 11·2 | 14·2 | m | 5 | 4 |
| 20 | 26 | 18·3 | 5 | 12·3 | 17·8 | 11·5 | 14 | m | 5 | 4 |
| 21 | 26 | 18 | 5 | 12·5 | 17·8 | 11·3 | 14 | f | 6 | 6 |
| 22 | 26 | 18 | 5 | 12·5 | 17·8 | 11·5 | 14 | f | 5 | 5 |
| 23 | 26 | 17·5 | 5 | 12 | 17 | 11·2 | 14 | f | 5 | 4 |
| 24 | 26 | 17·5 | 5 | 12 | 17·5 | 11·5 | 14·3 | f | 5 | 6 |
| 25 | 25·5 | 17·5 | 5 | 12 | 17·5 | 11·5 | 14 | m | 6 | 5 |
| 26 | 25·3 | 17·5 | 4·8 | 11·8 | 17 | 11 | 13·5 | f | 5 | 5 |
| 27 | 25·3 | 17·5 | 4·8 | 11·6 | 17 | 11 | 13·5 | m | 5 | 3 |
| 28 | 24·5 | 16·5 | 4·6 | 11·5 | 16·5 | 10·5 | 13·2 | f | 4 | 3 |
| 29 | 23·5 | 16 | 4·5 | 11·2 | 15·5 | 10 | 12·5 | f | 6 | 4 |
| 30 | 23·5 | 16·2 | 4·8 | 11·5 | 16·2 | 10·3 | 12·8 | m | 5 | 3 |



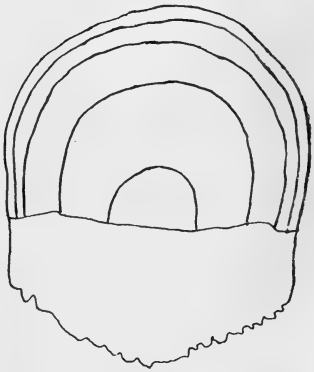
1.



2.



3.



4.

SCALES OF HERRING.

# THE SPAWNING OF THE PLAICE.

By B. STORROW.

In the report of last year appeared a short account of the spawning of the cod, the marked periodicity of which was noted. A similar periodicity, although rendered obscure by the number of fish in the tank, was also mentioned in connexion with the spawning of the plaice.

In order to obtain some evidence of this, a male and female plaice of * and 35 cm. respectively, and two males of 32 and 34 cm. and one female of 42 cm., were isolated on the 15th February, and observations were made from day to day as to the spawning of the isolated females. A record was also kept of the spawning of the plaice not isolated.

In the case where one male and one female were together the first eggs appeared on the 16th February and were not fertilised, as were also the next lot which was spawned on the 25th. Further spawning took place in March on the 5th, 8th, 20th and the 26th, but many of the eggs were not fertilised.

The female of 42 cm. spawned on the 17th, 22nd and the 28th of April, and on the 5th of May but no eggs were fertilised.

It is probable from few of the eggs being fertilised in the first case of isolation and none in the second that the males were not suitable, and that this would have some effect on the periodicity of the spawning of the female.

From the tank containing the other plaice, some 32 in number, first day eggs were obtained in February on the 24th, 27th and 29th; in March on every day with the exception of the 3rd, 5th, 10th and the 15th; in April on every day up to the 11th and afterwards on the 14th, 15th, 16th, 18th, 20th and the 22nd. In May newly spawned eggs were taken on the 6th and the 12th, but those of the latter date were not fertilised.

The average diameter of the eggs was 1·73 mm.†

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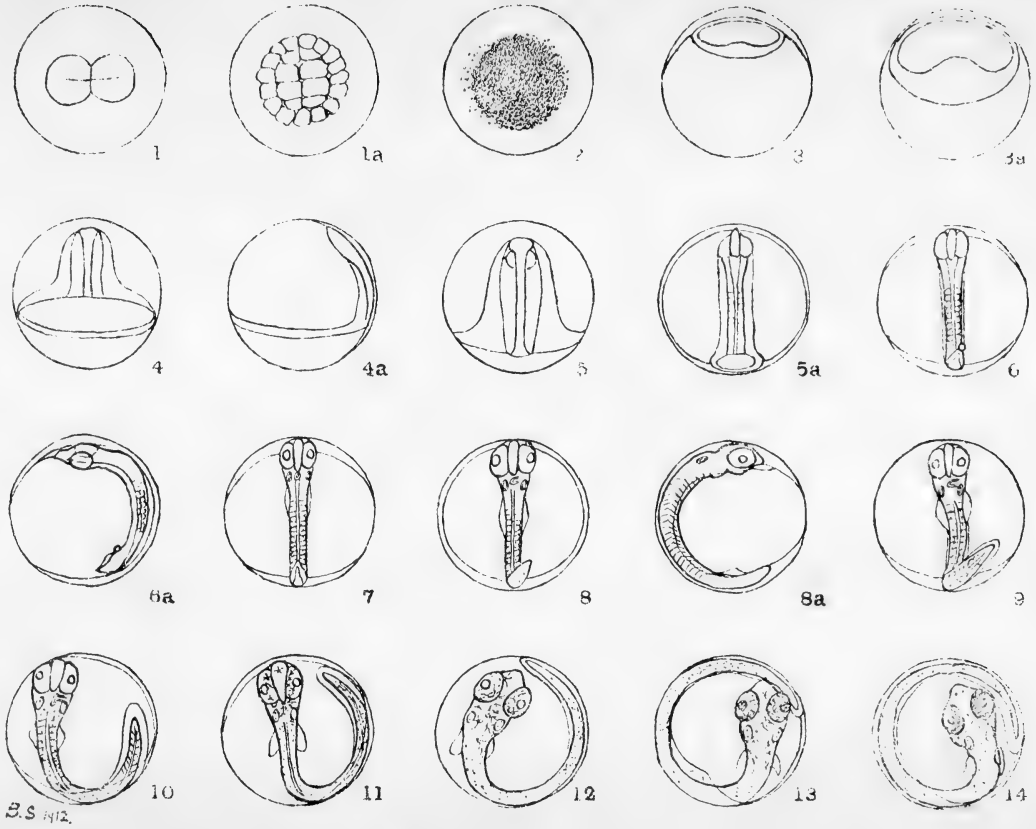
*Unfortunately the male was replaced in the plaice tank before measuring. It was smaller than the female.

†In the Report of last year p. 24, line 4, 1·28 cm. should read 1·28 mm.

The first larvae were observed on the 8th of March, the 14th day after spawning and the mean temperature of the water was 6·8° C. The time between spawning and hatching was found to vary. Some of the eggs spawned on the 10th and 14th of April and kept in separate glass vessels hatched on the 21st and 25th respectively, that is on the 12th day from spawning. During this period the mean temperature of the water was 8·1° C. Others spawned on the 6th of May hatched on the 15th or the 10th day from spawning, the mean temperature of the water being 9·9° C.

From the observations made, spawning took place in all cases in the morning, generally before 9 o'clock. The plate accompanying this account shows the growth made by the embryo from day to day for a period of 14 days between spawning and hatching. The number of eggs in the tanks was so large that it was necessary to take some thousands to sea in order to give them a chance of hatching. Samples have been taken representative of the stages of development for each day and it is hoped that this material will be of use for an account of the development of the plaice.




STAGES IN THE DEVELOPMENT OF THE PLAICE.—The figures refer to the days from spawning

# BIOLOGICAL INVESTIGATIONS.

During August and September a number of stations was visited, and by the aid of the "Evadne" material was collected for the purpose of indicating the nature of the bottom and surface life to be obtained during these two months.

In August, in the northern part of the region, larval decapods were abundant, the Zoëa and Metazoëa of Porcellana particularly occurring in large numbers. Copepods formed the bulk of the catches in September, the commonest taken being *Acartia clausi*. *Temora longicornis*, and *Centropages hamatus* were also plentiful. *Isias clavipes* was taken at Station 2 only, and there it occurred in large numbers, most being caught by the bottom net. *Evadne nordmanni* was taken at ten stations and was most abundant at Station 2. Sagitta was taken by the surface net at every station with the exception of St. Andrew's Bay, and there it was got in the bottom net.

With regard to the material obtained by the bottom net and dredge, the following facts are of interest. The richest haul of Echinoderms was made at Station 2. In St. Andrew's Bay *Ophiura ciliaris* was obtained in exceedingly large numbers. The undermentioned Copepods, although recorded for adjacent waters, are new to Northumberland: *Cyclopicera gracilicauda*, *Asellopsis hispida*, and *Bradya typica*:—

STATION 1, 4th Sept., 1911, 25 faths. E. ½ S. of Cullercoats.—Surface and Bottom.

STATION 2, 22nd Sept., 1911, 3 p.m., 32 faths., 8 mls. E. by S. of Cullercoats, drifting South with flood tide.—Surface and Bottom.

STATION 3, 16th Sept., 1911, 4 p.m., 10 faths. N.N.E. of Newbiggin.—Surface and Bottom.

STATION 4, 17th Aug., 1911, 14 faths. N. of Pinnacles and S.E. of Holy Island.—Surface and Bottom.

STATION 5, 17th Aug., 1911, 12 faths., passing through Wide Opens, Farne Islands.—Surface.

STATION 6, 16th Sept., 1911, 11 a.m., 10 faths., immediately S. of Inner Farne.—Surface and Bottom.

STATION 7, 14th Aug., 1911, 3 p.m., 15 faths. N.W. of Longstone and N. of Inner Farne, Holy Island beacons in line.—Surface and Bottom.

STATION 8, 17th Aug., 1911, 11 faths. E. by S. of Berwick Light.—Surface and Bottom.

STATION 9, 17th Aug., 1911, 14 faths. S.S.E. of St. Abbs and N.E. of Berwick Point.—Surface.

STATION 10, 15th Sept., 1911, 10 a.m., 27 faths. E. $\frac{3}{4}$ N. of May Island and N. $\frac{1}{2}$ W. of St. Abbs.—Surface and Bottom.

STATION 11, 15th Sept., 1911, 8 a.m., St. Andrew's Bay, 9 faths. E. of St. Andrews.—Surface and Bottom.

Surface and bottom catches were also made in 15 fathoms S.E. of Craster on Sept. 16th. These catches were accidentally mixed and are therefore given separately at the end of the tables.

In the tables the asterisks indicate the relative abundance of the organisms and groups mentioned. * the presence of the organism, ** in small numbers, *** in fairly large numbers, **** in large numbers, ***** in extremely large numbers.

## SURFACE.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FISH. | | | | | | | | | | | |
| Post larval goby ... ... ... | | | | | | | | | 1 | | |
| Post larval dragonet ... ... ... | | | | 1 | | | | | | | |
| Post larval sand-eel ... ... ... | | | | 1 | | | | | | | |
| Eggs of lemon dab ... ... ... | | 2 | | | 2 | | | | | | |
| Appendicularia ... ... ... ... | | | * | * | * | * | | | | * | |
| Astarte—young... ... ... ... | | | | | | | | | | * | |
| Ophiurans—young ... ... ... | | | | * | * | | | * | | | |
| Pluteus ... ... ... ... ... | | | | * | * | | | | | | |
| Larval Gasteropods ... ... ... | | ** | | * | | **** | * | * | * | *** | * |
| Larval Lamellibranchs ... ... ... | | * | * | | | | | | | * | |
| CRUSTACEANS. | | | | | | | | | | | |
| LARVAL DECAPODS ... ... | ** | ** | | **** | **** | * | **** | *** | ***** | * | ** |
| Macrura—Zoëa ... ... ... | | | | * | ** | | *† | | | | |
| Mysis ... ... ... | | | | * | * | | | | * | | |
| Anomura—Zoëa ... ... ... | | | | **‡ | **‡ | | | *‡ | ****‡ | | |
| Metazoëa ... ... | | * | | * | * | | * | * | * | 1 | * |
| Brachyura—Zoëa ... ... ... | * | | | * | * | * | * | * | * | | * |
| Megalopa ... ... | * | * | | | * | | **** | | * | 2 | * |
| AMPHIPODS. | | | | | | | | | | | |
| *Euthemisto compressa* (Goës) ... | | | | | | | | | * | | * |
| *Apherusa bispinosa* (Bate) ... ... | | * | | | | | | | | | |
| *Paratylus swammerdami* (M. Edw.) | | * | * | | | | * | | | | |
| COPEPODS. ... ... ... ... | ** | **** | *** | **** | **** | *** | *** | **** | *** | **** | *** |
| Nauplius ... ... ... ... | * | | | * | * | | * | | * | * | |
| *Calanus helgolandicus* (Claus) ... | | * | * | * | * | * | | * | * | *** | * |
| *Pseudocalanus elongatus*, Boeck ... | | | | * | | | * | * | | | |
| *Centropages typicus*, Kröyer ... | | ** | | | | | | | | | |
| *Centropages hamatus* (Lilljeborg) | * | ** | * | ** | ** | * | * | * | ** | * | * |
| *Isias clavipes*, Boeck ... ... | | * | | | | | | | | | |
| *Temora longicornis*, Müller... ... | * | ** | ** | ** | * | * | * | ** | ** | * | * |
| *Anomalocera patersoni*, Templeton. | | * | | * | * | | ** | * | * | | |
| *Acartia clausi*, Giesbrecht ... ... | * | **** | ** | * | ** | * | *** | ** | ** | ** | *** |
| *Acartia longiremis* (Lilljeborg) ... | | | * | * | * | | * | | * | | |
| *Longipedia scotti*, G. O. Sars ... | | | * | | | | | | | | |
| *Eupelte purpurocinta* (Norman) ... | | | * | | | | | | | | |
| *Oithona similis*, Claus ... ... | | | * | * | * | * | | * | | * | |
| Barnacle Nauplius ... ... ... | | | | | | * | * | * | | | |
| Cast Cuticle ... ... ... | | * | | | | | | | | | |
| *Evadne nordmanni*, S. Lovén ... | | **** | * | ** | ** | * | * | * | ** | ** | * |
| OSTRACODS ... ... ... ... | | | | | * | * | | | | ** | |
| WORMS. | | | | | | | | | | | |
| Polychaets ... ... ... ... | | * | | * | | | | | * | | |
| Tomopteris ... ... ... ... | | | | | | | | | * | | |
| Sagitta ... ... ... ... ... | ** | **** | * | ** | ** | ** | * | * | **** | *** | |
| Larval Polyzoa ... ... ... ... | | | | * | | | * | * | * | | |
| *Ceratium tripos* ... ... ... ... | * | *** | * | 1 | * | ** | | 1 | | ** | |
| *Ceratium furca* ... ... ... ... | | | | | | | * | | | | |
| *Ceratium fusus* ... ... ... ... | | | | | | * | | * | | | |
| Peridinium sp. ... ... ... ... | | | | | | * | | | * | | |
| Foraminifera ... ... ... ... | | | * | | | | | | | ** | |

†Young Lobster, third stage. ‡Porcellana.

## BOTTOM.

| | 1 | 2 | 3 | 4 | 6 | 7 | 8 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|
| **FISH.** | | | | | | | | | |
| Post larval gurnard ... ... ... ... | | | | | | | | * | |
| Post larval lumpsucker ... ... ... | | | | | * | | | | |
| Post larval herring ... ... ... ... | | * | | | | | | | |
| Young dab (*P. limanda*) ... ... ... | | | * | | | | | | |
| Appendicularia ... ... ... ... ... | | | | | | | | * | * |
| **ECHINODERMS.** | | | | | | | | | |
| *Cucumaria lactea*, F. & G. ... ... ... | | * | | | | | | | |
| *Solaster papposus*, Fabr. ... ... ... | | | | * | | | | | |
| *Asterias rubens*, Linn. ... ... ... | | * | | | | | | | 10 |
| *Ophiura ciliaris*, Linn. ... ... ... | | | | | | | | | ***** |
| *Ophiura albida*, Forbes ... ... ... | * | * | * | ** | | | | | |
| *Amphiura filiformis*, Müll. ... ... ... | | | * | | | | | | |
| *Ophiactis balli*, Thomp. ... ... ... | | * | | | | | | | |
| *Ophiopholis aculeata*, Linn. ... ... ... | | * | | | | | | | |
| *Ophiothrix fragilis*, Abilg. ... ... ... | | * | | | | | | | |
| *Echinus norvegicus*, Dub. & Kor. ... ... | | * | | | | | | | |
| *Echinus esculentus*, Linn. ... ... ... | | | | * | | | | | |
| *Spantangus purpureus*, Müll. ... ... | | * | | | | | | | |
| *Echinocardium flavescens*, Müll. ... ... | | * | | | | | | | |
| Young Ophiurans ... ... ... ... | | | | | | * | * | * | * |
| Pluteus ... ... ... ... ... ... | | | | | | | * | * | |
| **MOLLUSCS.** | | | | | | | | | |
| *Nucula nitida*, G. B. Sowerby ... ... | | | | | | | | | * |
| *Nuculana minuta* (Müll.) ... ... ... | | d.s.† | | | | | | | |
| *Anomia ephippium*, Linn. ... ... ... | | d.s. | * | | | | | | |
| *Anomia patelliformis*, Linn. ... ... ... | | d.s. | | | | | | | |
| *Volsella barbata* (Linn.) ... ... ... | | d.s. | | | | | | | |
| *Modiolaria discrepans* (Leach) ... ... | | * | | | | | | | |
| *Pecten pusio* (Linn.) ... ... ... ... | | * | | | | | | | |
| *Pecten opercularis* (Linn.) ... ... ... | | d.s. | | | | | | | |
| *Pecten striatus* Müll. ... ... ... ... | | d.s. | | | | | | | |
| *Astarte sulcata* (da Costa) ... ... ... | | * | | | | | | | |
| *Astarte compressa* (Mont.) ... ... ... | * | * | | | | | | | |
| *Cyprina islandica* (Linn.) ... ... ... | | d.s. | | | | | | | |
| *Kellia suborbicularis* (Mont.) ... ... ... | | ** | | | | | | | |
| *Syndosmya alba* (Wood) ... ... ... | | | | | | | | | * |
| *Tellina fabula*, Gronov. ... ... ... | | | | | | | | | ** |
| *Mactra stultorum*, Linn. ... ... ... | | | | | | | | | ** |
| *Spisula solida* (Linn.) ... ... ... ... | | d.s. | | | | | | | |
| *Spisula subtruncata* (da Costa) ... ... | | | | | * | | | | |
| *Dosinia lupina* (Linn.) ... ... ... | | d.s. | | | | | | | |
| *Venus casina*, Linn. ... ... ... ... | | | | | | | | | * |
| *Venus gallina*, Linn. ... ... ... ... | | d.s. | | | | | | | |
| *Tapes virgineus* (Linn.) ... ... ... | | | | | | * | | | |
| *Tapes pullastra* (Mont.) ... ... ... | | d.s. | | | | | | | |
| *Cardium echinatum*, Linn. ... ... ... | | | | | | | | | jv. |
| *Cardium fasciatum*, Mont. ... ... ... | | * | | | | | | | |
| *Gari, tellinella*, Lamk. ... ... ... | d.s. | | | | | | | | |
| *Ensis ensis* (Linn.) ... ... ... ... | | | | | | | | | ** |
| *Saxicava arctica* (Linn.) ... ... ... | | ** | | | | | | | |
| *Thracia fragilis*, Penn. ... ... ... | | | | | | | | | * |
| *Dentalium entalis*, Linn. ... ... ... | | d.s. | | | | | | | |
| *Gibbula tumida* (Mont.) ... ... ... | | | | * | | | | | * |
| *Eulima bilineata* (Alder) ... ... ... | | * | | | | | | | |
| *Turritella communis*, Lamk. ... ... ... | | * | | | | | | | |
| *Buccinum undatum*, Linn. ... ... ... | | d.s. | | | | | | | |
| *Nassa incrassata* (Ström) ... ... ... | d.s. | * | * | | | | | | |

†Dead shells.

BOTTOM—*continued.*

| | 1. | 2. | 3. | 4. | 6. | 7. | 8. | 10. | 11. |
|---|---|---|---|---|---|---|---|---|---|
| Larval Gasteropods ... ... ... ... | | ** | ** | * | *** | * | * | *** | ** |
| Larval Lamellibranchs ... ... ... ... | | * | *** | | | * | * | ** | ** |
| CRUSTACEANS. | | | | | | | | | |
| DECAPODS. | | | | | | | | | |
| *Ebalia tuberosa* (Penn.) ... ... ... | | * | | | | | | | |
| *Portunus holsatus* (Fabr.) ... ... ... | | | | | * | | | | |
| *Hyas coarctatus*, Leach ... ... ... | | * | | | | | | | |
| *Pagurus bernhardus* (Linn.) ... ... | | * | | | | | | | |
| *Spirontocaris cranchi* (Leach) ... ... | | | * | | | | | | |
| *Hippolyte varians*, Leach ... ... ... | | | * | | | | | | |
| *Pandalus montagui*, Leach ... ... ... | | | * | | | | | | |
| LARVAL DECAPODS ... ... ... | | *** | ** | | * | **** | *** | *** | *** |
| Macrura Zoëa ... ... ... ... | | | | | | | * | | * |
| Mysis ... ... ... ... | | | * | | | * | * | * | * |
| Anomura Zoëa ... ... ... ... | | * | * | 1 | * | ***† | **† | * | * |
| Metazoëa... ... ... ... | | * | * | | * | * | * | * | * |
| Brachyura Zoëa ... ... ... ... | | ** | * | | * | ** | * | * | * |
| Megalopa ... ... ... | | * | * | | * | * | | * | * |
| CUMACEA. | | | | | | | | | |
| *Pseudocuma cercaria* (V. Beneden) ... | | | * | | | | | | |
| ISOPODS. | | | | | | | | | |
| *Gnathia maxillaris* (Mont.) ... ... | | * | | | | | | | |
| *Astacilla longicornis* (Sowerby) ... ... | | * | | | | | | | |
| AMPHIPODS. | | | | | | | | | |
| *Euthemisto compressa* (Goës) ... ... | | *** | * | | * | jv. | | jv. | jv. |
| *Bathyporeia pelagica* (Bate) ... ... | | | * | | | | | | |
| *Ampelisca brevicornis* (A. Costa) ... ... | | | 3 | | | | | | |
| *Ampelisca macrocephala*, Lillj. ... ... | * | | | | | | | | |
| *Stenothoe* sp. ... ... ... ... ... | | | | | | | | | * |
| *Metopa norvegica* (Lillj.) ... ... ... | | | | | | * | | | |
| *Metopa robusta*, G. O. Sars... ... ... | | | | | | * | | | |
| *Perioculodes longimanus* (B. & W.) ... | | | * | | | | | | |
| *Iphimedia minuta*, G. O. Sars ... ... | | | * | | | | | | |
| *Argissa hamatipes* (Norman) ... ... | | | | | * | | | * | |
| *Apherusa bispinosa* (Bate) ... ... | | | | | * | | | * | |
| *Melita obtusata* (Mont.) ... ... ... | | **** | | | | | | | *** |
| *Paratylus swammerdami* (M. Edw.) ... | | | **** | | * | jv. | * | | |
| *Erichthonius hunteri* (Bate) ... ... | | | * | | | | | | |
| *Erichthonius abditus* (Temp.) ... ... | * | | | | | * | | | |
| *Pseudoprotella phasma* (Mont.) ... ... | | * | | | | | | | |
| *Caprella linearis* (Linn.) ... ... ... | | * | | | | | | | |
| *Periambus typicus* (Kröyer)... ... ... | | | | | | | | | **** |
| COPEPODS ... ... ... ... ... | | **** | **** | * | *** | **** | **** | **** | **** |
| Nauplius ... ... ... ... ... | | | | | * | | * | * | |
| *Calanus helgolandicus* (Claus) ... ... | | ** | * | | * | ** | * | **** | ** |
| *Pseudocalanus elongatus*, Boeck ... ... | | * | * | | | * | * | * | |
| *Centropages typicus*, Kröyer ... ... | | * | | | | | | | |
| *Centropages hamatus* (Lillj.) ... ... | | | * | | * | * | ** | | * |
| *Isias clavipes*, Boeck... ... ... ... | | **** | | | | | | | |
| *Temora longicornis*, Müll. ... ... ... | | **** | *** | | ** | *** | * | **** | *** |
| *Anomalocera patersonsi*, Temp. ... ... | | | | | * | | * | | |
| *Acartia clausi*, Giesb. ... ... ... | | ** | *** | | * | *** | ** | ** | **** |
| *Acartia longiremis* (Lillj.) ... ... ... | | | * | | | | | * | |
| *Longipedia coronata*, Claus ... ... | | * | | | * | | | | |

† Porcellana common.

BOTTOM—*continued.*

| | 1. | 2. | 3. | 4. | 6. | 7. | 8. | 10. | 11. |
|---|---|---|---|---|---|---|---|---|---|
| COPEPODS—CONTINUED. | | | | | | | | | |
| *Longipedia scotti*, G. O. Sars ... ... | | | * | | | | | | * |
| *Ectinosoma sarsi*, Boeck ... ... ... | | * | | | | | | | |
| *Alteutha interrupta* (Goodsir) ... ... | | | * | | | | | | |
| *Eupelte purpurocincta*, (Norm.) ... ... | | | ** | | | * | | | |
| *Tisbe furcata* (Baird) ... ... ... | | | | | * | | | | |
| *Thalestris longimana*, Claus ... ... | | | * | | | | | | |
| *Rhynchothalestris rufocincta* (Norm.) ... | | | * | | | | | | |
| *Dactylopusia tisboides* (Claus) ... ... | | | | * | | | | | * |
| *Amphiascus tenuiremis* (Brady) ... ... | | * | | | | | | | |
| *Diosaccus tenuicornis* (Claus) ... ... | | | | | * | | | | |
| *Laophonte cornuta* (Philippi) ... ... | | | | | * | | | | |
| *Oithona similis*, Claus ... ... ... | | * | * | | * | * | * | * | * |
| *Cyclopicera gracilicauda*, Brady ... ... | | | * | | | | | | |
| *Acontiphorus scutatus*, B. & Robt. ... | | * | | | | | | | * |
| *Pseudanthessius thorelli* (B. & Robt.) ... | | | | | | | | | * |
| Barnacle Nauplius ... ... ... ... | | | | | | * | | * | * |
| *Evadne nordmanni* ... ... ... ... | | ** | | | * | ** | * | * | *** |
| OSTRACODS ... ... ... ... ... | | * | * | * | | * | | ** | * |
| ACARINA. | | | | | | | | | |
| *Halacarus granulatus*, Hodge ... ... | | * | | * | | | | | |
| *Leptognathus falcatus*, Hodge ... ... | | * | | | | | | | |
| WORMS. | | | | | | | | | |
| Polychaets ... ... ... ... ... | | ** | * | * | | * | * | * | * |
| Tomopteris ... ... ... ... ... | | * | | | | | | * | |
| Serpula ... ... ... ... ... ... | | * | | * | | | | | |
| Sagitta ... ... ... ... ... ... | | **** | * | * | * | **** | *** | **** | * |
| POLYZOA. | | | | | | | | | |
| *Gemellaria loricata*, Linn. ... ... ... | * | | | | * | | | | |
| *Scrupocellaria scruposa*, Linn. ... ... | | * | | | | | | | |
| *Cellaria fistulosa*, Linn. ... ... ... | * | | | | | | | | |
| *Flustra securifrons*, Pall. ... ... ... | | * | | | | | | | |
| *Cellepora sp.* ... ... ... ... ... | | | | | | * | | | |
| *Crisia denticulata*, Lamk. ... ... ... | | * | | | | | | | |
| Larval Polyzoa ... ... ... ... ... | | | * | | | * | * | | * |
| COELENTERATES. | | | | | | | | | |
| *Hydractinia echinata*, Flem. ... ... ... | | * | | | | | | | |
| *Tubularia sp.* ... ... ... ... ... | | * | | | | | | | |
| *Obelia geniculata*, Linn. ... ... ... | | | | | * | | | | |
| *Sertularia abietina*, Linn. ... ... ... | | * | * | | * | | | | |
| *Hydrallmannia falcata*, Linn. ... ... | | * | | | * | | | | |
| *Plumularia pinnata*, Lamk. ... ... ... | | * | | | | * | | | |
| *Plumularia setacea*, Ellis ... ... ... | | | | | * | | | | |
| *Plumularia catherina*, Johnst. ... ... | * | | | | | | | | |
| Pleurobrachia ... ... ... ... ... | | | | | | | | * | * |
| Foraminifera ... ... ... ... ... | | * | | | * | | | ** | * |
| *Ceratium tripos* ... ... ... ... ... | | ** | | 1 | * | | 1 | * | * |
| *Ceratium fusus* ... ... ... ... ... | | * | | | | * | | | |

Sept. 16th, 1911, 1 p.m., 15 faths. S.E. of Craster.—Surface and Bottom:—

Echinoderms: *Echinus esculentus*, Asterias jv., Ophiurans jv.

Molluscs: *Nucula nitida*, *Anomia patelliformis* (d.s.), *Pecten opercularis* (d.s.), *Syndosmya alba* (d.s.), *Spisula subtruncatà*, *Cardium edule* (d.s.), *Ensis ensis*, *Odostomia unidentata*, F. & H., *Ondina divisa* (J. Adams), Larval Gasteropods, Larval Lamellibranchs.

Larval Decapods *: Macrura, Mysis; Anomura, Metazoea; Brachyura, Megalops.

Amphipods: *Ampelisca spinipes*, Boeck; *Argissa hamatipes* (Norm.), *Paratylus swammerdami* (M.-Edw.).

Copepods: *Calanus helgolandicus*, *Pseudocalanus elongatus*, *Temora longicornis*, *Acartia clausi*, *Acartia longiremis*, *Longipedia coronata*, *Bradya typica*, Boeck, *Eupelte purpurocincta*, *Asellopsis hispida*, B. & R., *Oithona similis*.

Cumacea, Barnacle-cast cuticle, *Evadne nordmanni*.

Pycnogons: *Nymphon rubrum*.

Polychaets *, Sagitta ***, *Sertularia abietina*, Foraminifera, *Ceratium tripos*.

MATERIAL COLLECTED BY B. STORROW DURING JULY AND AUGUST OF 1911, WHEN ON BOARD TRAWLERS FISHING ON THE LOCAL PRAWN GROUND, TOGETHER WITH THE CATCHES OF EDIBLE FISH THEN MADE.

Four hauls were made during each trip, and the ground fished and the stations where surface catches were made are as follows :—

(A.) 11th July, 1911, 1st haul 10 a.m. to 2 p.m., 38 faths. E. by N. of St. Mary's Island, to 41 faths. E.S.E. of Coquet Island.

(B.) ,, 2nd haul, 2·30 p.m. to 6·45 p.m., 40 to 42 faths. E.S.E. to E. of Coquet Island, steaming in a circle.

(C.) ,, 3rd haul, 7·15 p.m. to 11·20 p.m., 40 faths. N.E. of Newbiggin to 48 faths. E.S.E. of Coquet Island.

(D.) ,, 4th haul, 11·50 p.m. to 3·40 a.m. 12th July, 48 faths. E.S.E. of Coquet Island to 40 faths. S.E. of Coquet Island.

(E.) 30th August, 1911, 1st haul, 9·45 a.m. to 1·45 p.m., 34 faths E.N.E. of Tyne to 36 faths. S.E. ½ S. of Coquet Island.

(F.) ,, 2nd haul, 2·15 p.m. to 7 p.m., 36 to 37 faths. E. of Newbiggin, steaming in a circle.

(G.) ,, 3rd haul, 7·30 p.m. to 12·30 a.m. 31st August, 37 faths. E.N.E. ½ E. of St. Mary's Island, S.S.E. to 38 faths. then to 37 faths. E. ½ S. of St. Mary's Island.

(H.) 31st August, 1911, 4th haul, 1 a.m. to 5 a.m., 37 faths. E. ½ S. of St. Mary's Island, 34 faths. N.E. of Shields, 37 faths N.E. by N. of Shields and back to 34 faths. N.E. of Shields.

SURFACE :—

(A.) 11th July, 1911, 3 p.m., 41 faths. E.S.E. of Coquet Island.

(B.) ,, 7 p.m., 40 faths. N.E. of Newbiggin.

(C.) ,, 11·20 p.m., 48 faths. E.S.E. of Coquet Island.

(D.) 12th July, 1911, 3·30 a.m., 40 faths. S.E. of Coquet Island.

(E.) 30th Aug., 1911, 2 p.m., 36 faths. S.E. ½ S. of Coquet Island.

(F.) ,, 7 p.m., 37 faths. E.N.E. ½ E. of St. Mary's Island.

(G.) 31st Aug., 1911, 5 a.m., 34 faths. N.E. of Shields.

## SURFACE.

| | A. | B. | C. | D. | E. | F. | G. | H. |
|---|---|---|---|---|---|---|---|---|
| FISH EGGS. | | | | | | | | |
| Lemon Dab | * | | | | | | | |
| Dragonet? | ** | * | | * | | | | |
| Appendicularia | * | | | | | | * | |
| Pluteus | | * | *** | * | | | | |
| Larval Lamellibranchs | * | | ***** | **** | ** | | | |
| Larval Gasteropods | | | * | ** | | | | |
| Brachyura Zoëa | | * | | | | | * | |
| Megalopa | | | | | | * | | |
| COPEPODS. | | | | | | | | |
| Nauplius and young stages | **** | *** | * | **** | *** | *** | ** | |
| *Calanus helgolandicus* | * | **** | | *** | | | | |
| *Pseudocalanus elongatus* | | | * | | | * | | |
| *Acartia longiremis* | * | | | | | | | |
| *Acartia clausi* | | | | | * | ** | | |
| *Oithona similis* | | * | * | * | * | * | * | |
| Barnacle nauplius | | | * | | | | | |
| *Evadne nordmanni* | * | | | | | | | |
| *Podon polyphemoides* | * | | * | | | | | |
| Sagitta | * | * | | | * | * | * | |
| Peridinium sp. | * | | | | | | | |
| *Ceratium tripos* | **** | **** | **** | ***** | **** | *** | *** | |
| *Ceratium furca* | ** | ** | ** | ** | *** | | | |
| *Ceratium fusus* | * | | | ** | ** | * | | |

## BOTTOM.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Norway Lobster* | 65 | 20 | 109 | 219 | 238 | 3 cwts. | 6 cwts. | 3 cwts |
| FISH | | | | | | | | |
| Cod, large | 25 | 15 | 34 | 20 | | | | |
| medium | 15 st. | 5 st. | 10 st. | 10 st. | 1 st. | $2\frac{1}{2}$ st. | 4 | |
| Haddock | 10 st. | 8 st. | 5 st. | 5 st. | 30 st. | 55 st. | 5 st. | 15 st. |
| Whiting | $2\frac{1}{2}$ st. | | | | 2 st. | 8 st. | | 4 st. |
| Cod, Haddock, Whiting small | 2 st. | 2 st. | 2 st. | 2 st. | 12 st. | | | |
| Coalfish | 10 | 4 | 9 | | | | | |
| Ling | | 2 | 1 | 1 | | | | |
| Catfish | 1 | 4 | | | | | 2 | |
| Grey Gurnard | 2 | 2 | 5 | 4 | 1 st. | 2 st. | | |
| Angler | 3 | 3 | 2 | 1 | 6 | 20 | | 5 |
| Halibut | | | | | | | 1 | |
| Turbot | 1 | | | | | | | |
| Plaice, Lemon Dab, Witch large | 3 st. | 6 st. | 6 st. | 6 st. | 1 st.<br>$1\frac{1}{2}$ st. | 3<br>3 st.<br>3 st. | 3 st. | |
| Plaice, Lemon Dab, Witch small | | 1 st. | 2 st. | 2 st. | 1 st. | 2 st. | 3 st. | 2 st. |
| Skate | 6 | 5 | 26 | 10 | 3 | | 2 | |
| Herring | 6 | | 2 | | | | | |
| Pogge | | | | | | 1 | | |
| Dragonet | | | | | | | | 1 |
| Plaice eggs | 2 | | | | | | | |
| ASCIDIANS. | | | | | | | | |
| *Ascidia sordida*, A. & H. | 2 | * | | | * | * | | |

*A—E in numbers. F—H in cwts.

BOTTOM.—*continued.*

| | A. | B. | C. | D. | E. | F. | G. | H. |
|---|---|---|---|---|---|---|---|---|
| ECHINODERMS. | | | | | | | | |
| *Asterias rubens*, Linn ... ... ... | 3 | | | | * | | | |
| *Hippasterias phrygiana* (Parel.) ... | | | | 1 | | | | |
| MOLLUSCS. | | | | | | | | |
| *Dosinia exoleta* (Linn.) ... ... ... | | | | | | * d.s. | | |
| *Saxicava arctica* (Linn.) ... ... | * | * | | | | * | | |
| *Dentalium entalis*, Linn. ... ... | | | | | | | | *** |
| *Gibbula tumida* (Mont.) ... ... | | * | | | | | | |
| *Natica catena* (da Costa) ... ... | | | | | * | | | |
| *Velutina laevigata* (Penn.) ... ... | | | | | * | | | |
| *Turritella communis*, Lamk. ... ... | | | | | * | * d.s. | | *** |
| *Neptunea antiqua* (Linn.) ... ... | 2 | * | | * | ** | | | |
| *Bela turricula* (Mont.) ... ... ... | | | | | | | | * |
| *Coryphella rufibranchialis* (John.) ... | * | * | | | * | * | | * |
| *Pleurophyllidia loveni*, Bergh. ... | | | | | 1 | | | |
| *Tritonia hombergi*, Cuv. ... ... | * | * | | | | | | |
| PYCNOGONS. | | | | | | | | |
| *Pycnogonum littorale*, Ström ... ... | 2 | | | | | | | |
| *Nymphon stromi*, Kröyer ... ... | 1 | | | | | | | |
| CRUSTACEANS. | | | | | | | | |
| *Macropodia rostrata* (Linn.) ... ... | | | | | | * | | |
| *Hyas coarctatus*, Leach... ... .. | | | | | | * | | * |
| *Lithodes maia* (Linn.) ... ... ... | | | 1 | 1 | | | | |
| *Pagurus bernhardus* (Linn.) ... ... | | | | 1 | | | | |
| *Calanus helgolandicus* (Claus)... ... | * | * | | | | | | |
| *Acartia clausi*, Giesb. ... ... ... | | | | | | * | | |
| ANNELIDS. | | | | | | | | |
| *Aphrodite aculeata*, Linn. ... ... | | | | 1 | 1 | | | 3 |
| *Lepidonotus squamatus*, Linn. ... ... | | ** | | | | | | |
| *Eunoa nodosa*, M. Sars ... ... ... | | * | | | | | | |
| *Lagisca floccosa*, Savig. ... ... | | * | | | | | | |
| *Nereis pelagica*, Linn. ... ... ... | * | | | | * | | | |
| *Nereis diversicolor*, Müll. ... ... | | | | | | * | | |
| *Carinella annulata*, Mont. ... ... | | | | | 6 | 3 | | |
| POLYZOA. | | | | | | | | |
| *Gemellaria loricata*, Linn. ... ... | | | | | * | *** | | |
| *Flustra foliacea*, Linn. ... ... | | | | | | * | | |
| *Flustra securifrons*, Pall. ... ... | | * | | | | | | |
| *Membranipora unicornis*, Flem. ... | | | | | | * | | |
| COELENTERATES. | | | | | | | | |
| *Bougainvillia ramosa*, V. Ben. ... | | | | | ** | | | |
| *Tubularia indivisa*, Linn. ... ... | * | * | | | | | | |
| *Tubularia larynx*, Ell. & Sol. ... ... | * | | | | | | | |
| *Halecium halecinum*, Linn. ... ... | | | | | * | | | |
| *Sertularia abietina*, Linn. ... ... | | * | | | | | | |
| *Hydrallmannia falcata*, Linn. ... | | | | | | * | | |
| *Thuiaria thuia*, Linn. ... ... | * | | | | | * | | |
| *Calycella syringa*, Linn. ... ... | | | | | | * | | |
| *Alcyonium digitatum*, Linn. ... ... | * | * | | | 6 | | | |
| *Bolocera tuediae*, Johnst. ... ... | | ** | | | | | | |
| *Actinoloba dianthus* (Blainv.) ... ... | ** | ** | | * | | | | |
| Foraminifera ... ... ... ... | * | | | | | | | |

# REPORT ON THE CONDITION OF THE WATER OF THE TYNE DURING OCTOBER, 1911.

By PROFESSOR A. MEEK, with the collaboration of PROFESSOR BEDSON, PROFESSOR HUTCHENS, G. SISSON and B. STORROW.

It having been reported to me that the pollution of the Tyne had become so bad, especially during a dry season, I made arrangements when the "Evadne" was in the river last October to get a number of samples taken. The samples were analysed in the Chemical Laboratories of Armstrong College by Mr. Herbert Blair, under the direction of Professor Bedson, and certain samples were also examined bacteriologically by Professor Hutchens, of the Durham University College of Medicine. At the same time biological collections were made and examined by Mr. Storrow and myself.

The first series of samples were taken on October 20th, from the mouth of the Tyne to Newcastle. There were 11 samples in all. The first eight were taken from the piers to W. Dobson's yard on the flood tide, and consisted practically of sea water. The last three were taken from Hoyle, Robson and Barnett's to Newcastle Quay, at the beginning of the ebb. These contained 80, 70, and 60 per cent. of sea water respectively. The average analysis of the first eight shows the presence of free ammonia to the extent of 1·2 parts per million, and of albuminoid ammonia of ·17 per million. This shows that for the lower reaches of the Tyne the water is of sufficient purity for all purposes of fish life, many marine forms of animal and plant life and even a larval fish being obtained in the collateral samples examined for these.

With regard to the last three which were taken at a time when the fresh water began to mix with the salt water a decreasing degree of purity is evidenced. The free ammonia goes up to 2·13 parts, and the albuminoid ammonia to ·24 parts per million as compared with the first eight samples.

On October 27th a further series of samples was taken in the neighbourhood of Newcastle at about low tide. There was in consequence a small admixture only of sea water. The average of six of these for the free ammonia is 3·5, and for the albuminoid ammonia ·35 parts per million. One sample, taken within the mouth of the Ouseburn, showed free ammonia to the extent of 9.15, and of albuminoid ammonia ·8 parts per million.

Comparing the results of these analyses it is evident that as the sea water diminishes the pollution increases from 1·2 to 9·15 for free ammonia, and from ·17 to ·80 for albuminoid ammonia per million.

At the same time samples were taken and sent to Professor Hutchens for bacteriological examination. He reported that at least 1,000 *Bacillus coli* per c.c. were found in each.

These figures therefore give better results than might have been expected. But it has to be stated that the samples were taken after and during heavy rain storms, which evidently diluted the sewage contamination considerably. The present experiment is therefore rather inconclusive. But an attempt ought to be made to continue the observations during the summer when the salmon ascend the river. For, apart from its sanitary bearing, the pollution of the Tyne has an important connexion with the work of the River Tyne Conservancy. Many of the members believe that the pollution is increasing from year to year to such an extent that there is danger of the Tyne ceasing to be a salmon river. There are evidently many other sources of pollution than those indicated in the above analyses. For example, the sample taken from the Teams was black with creosote, a most poisonous and corrosive substance, and it cannot be washed away. Other sources might be mentioned, paper mills, drainage from tank waste heaps, sulphur and copper works, paint works, colliery water, gas works, tanneries and the like.

In the summer of 1901 Dr. Noel Paton, of Edinburgh, investigated and reported on the condition of the Tyne, and he stated in that report, with reference to the tributaries :—"In the low part of the Team no fish are ever seen of any kind; it is very much polluted by sewage from several places, colliery water, and a brown-paper mill. The Derwent is the same. It runs through a mining country, has three paper mills* and other works on it." It may be presumed that matters have got worse rather than better since that report was written.

NOTE. With reference to the figures given in this report, the free ammonia and albuminoid ammonia are evidences of the extent of organic impurity, and indicate putrifying animal and vegetable matter. No figures are given as to the poisonous chemical substances from the works mentioned above, which are really more important with regard to the life of fish.

* The paper works on the Derwent have ceased to work for some years.

# TYNE WATER SAMPLES.

October 20th, 1911.

| No. | 60° F. specific gravity water = 1000·0. | % Solids after gentle ignition W / V. | Calculated T. Solids % W / V. | % Chlorine % W / V. | N. H. free 1:1000000 | N. H.$^3$ Alb. 1:1000000 | Observer. | Calculated Salinity 1:1000 | % Salt Water. | Origin of Sample. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1023·824 | 3·394 | 3·45 | 1·940 | 0·65 | 0·20 | B. | 35·3 | | Just inside piers. |
| 2 | 1024·000 | ... | 3·47 | 1·984 | 1·20 | 0·52 | B. | 36·0 | | Lloyd's Hailing Station. |
| 3 | 1023·994 | ... | 3·47 | 1·974 | 1·00 | 0·20 | B. | 35·9 | 100 % | Smith's Dock. |
| 4 | 1023·610 | ... | 3·42 | 1·930 | 0·80 | 0·15 | B. | 35·1 | | Howdon Dock entrance. |
| 5 | 1023·550 | ... | 3·42 | 1·920 | 0·58 | 0·077 | B. | 35·0 | | Opposite west end of Howdon Dock. |
| 6 | 1022·430 | ... | 3·25 | 1·840 | 0·85 | 0·14 | P. | 33·5 | 96· | Opposite Cleland's. |
| 7 | 1021·180 | ... | 3·065 | 1·760 | 1·60 | 0·20 | P. | 32·1 | 91 | Swan & Hunter's. |
| 8 | 1020·500 | ... | 2·910 | 1·700 | 1·73 | 0·40 | P. | 31·0 | 89·5 | W. Dobson & Co. |
| 9 | 1019·932 | ... | 2·895 | 1·660 | 1·25 | 0·13 | B. | 30·3 | 86·5 | Hoyle, Robson, Barnett & Co. |
| 10 | 1017·390 | ... | 2·600 | 1·450 | 2·00 | 0·15 | B. P. | 26·5 | 75·4 | Just below Ouseburn. |
| 11 | 1014·479 | 2·130 | 2·103 | 1·260 | 2·13 | 0·24 | B. | 23·0 | 65·7 | Newcastle Quay, Low Level, near wall. |

All samples taken on the north side of river and well away from shore, and from 3 to 4 feet below the surface.

High water or easy water until reaching Dobson's (No. 8) when ebb commenced.

P. PHILLIPS BEDSON.

*November 7th, 1911.*

# TYNE WATER SAMPLES.

## October 27th, 1911.

| No. | Specific gravity at 60° F. | Calculated T. solids. % W / V. | Chlorine % W / V. | N. $H^3$ free 1:1000000 | N. $H^3$ Alb. 1:1000000 | Origin of Sample. |
|---|---|---|---|---|---|---|
| 1 | 1006 | 0·6 | 0·333 | 9·15 | 0·8 | Ouseburn entrance (inside). |
| 2 | ... | 1·1 | 0·7 | 1·0 | 0·1 | Above Wood, Skinner. |
| 3 | ... | 1·0 | 0·65 | 1·3 | 0·3 | Holzapfel. |
| 4 | ... | 0·85 | 0·544 | 7·0 | 0·44 | Between Holzapfel and Grindstone Quay. |
| 5 | ... | 0·8 | 0·47 | 1·0 | 0·25 | High Felling Coal Staithes. |
| 6 | ... | 0·35 | 0·2 | 2·0 | 0·3 | Between King Edward & Redheugh Bridges. |
| 7 | ... | 0·2 | 0·04 | 3·5 | 0·35 | Entrance to Team Gut. |

## BIOLOGICAL SAMPLES (taken with tow net).

The asterisks refer to relative numbers present in each.
* occurring ** common *** very common

20 Oct., 1911.—No. 1. Copepoda:* *Acartia clausi* *, *Anomalocera patersoni*, *Oithona similis*, Nauplius, and other larval stages
Cirripedia. Barnacles—Cast cuticles.
Amphipoda: *Euthemisto compressa* (1) small variety.
Isopoda: *Idothea baltica* (3).
Larval Gasteropods.
*Ceratium tripos* *.
Diatoms.
Solid matter: fine sand, cinders, coal, and vegetable matter ***.

No. 2. Copepoda:* *Acartia clausi*,* *Centropages hamatus*,* *Centropages typicus*, *Pseudocalanus elongatus*, *Anomalocera patersoni*, *Oithona similis*, Nauplius.

Amphipoda :—*Paratylus swammerdami* (3).
Cirripedia : Barnacles—Cast cuticles.
Larval Gasteropods.
Sagitta.
Pleurobrachia (2).
*Ceratium tripos.*
Diatoms.
Solid matter : *** As in No. 1.

No. 3. Copepoda : ** *Acartia clausi, Centropages hamatus, Centropages typicus, Pseudocalanus elongatus, Anomalocera patersoni, Oithona similis, Eurytemora affinis,* Nauplius.
Cirripedia : Barnacles—Cast cuticles.
Sagitta.
Pleurobrachia (38).
*Ceratium tripos.*
Diatoms.
Solid matter *** As in No. 1.

No. 4. Copepoda : * *Acartia clausi* * *Temora longicornis, Eurytemora velox, Eurytemora affinis, Centropages hamatus, Pseudocalanus elongatus, Oithona similis, Longipedia scotti,* Nauplius.
Amphipoda : *Euthemisto compressa* (2).
*Paratylus swammerdami :* cast cuticle.
Larval Gasteropods.
Sagitta.
Pleurobrachia (2), Sarsia (3).
*Ceratium tripos**, *Ceratium furca.*
Diatoms.
Solid matter *** As in No. 1.

No. 5. Copepoda : * *Acartia clausi, Eurytemora velox,* * *Eurytemora affinis, Pseudocalanus elongatus, Anomalocera patersoni, Oithona similis,* Nauplius and other larval stages.
Amphipoda : *Euthemisto compressa* (9), larger variety (1).
*Paratylus swammerdami* (1).
*Amathilla homari* (1).
Larval Gasteropods.
Tomopteris (1).
Pleurobrachia (1), Sarsia (9).
*Ceratium tripos* * *Ceratium furca.*
Diatoms.
Solid matters *** As in No. 1, with the addition of seeds.

No. 6. Copepoda :** *Acartia clausi*, *Temora longicornis*, *Eurytemora velox* ** *Eurytemora affinis*, *Centropages hamatus*, *Pseudocalanus elongatus*. *Oithona similis**, Nauplius.
Amphipoda : *Euthemisto compressa* (3).
Larval Gasteropods *.
Tomopteris (2), Nematodes (2).
*Ceratium tripos* *.
Diatoms.
Solid matter ** As in No. 1.

No. 7. Post-larval Herring.
Copepoda *** *Acartia clausi*, *Eurytemora velox* ***, *Eurytemora affinis*, *Oithona similis* Nauplius and other larval stages.
Larval Gasteropods.
Tomopteris.
Sarsia (1).
*Ceratium tripos*.
Diatoms.
Solid matter * As in No. 1, but with small amount of vegetable matter.

No. 8. Copepoda :** *Acartia clausi*, *Eurytemora velox* *, *Eurytemora affinis*, *Centropages hamatus*, *Oithona similis*, Nauplius and other larval stages.
*Ceratium tripos*.
Diatoms.
Solid matter *** As in No. 1.

No. 9. Copepoda *** *Eurytemora velox** *Eurytemora affinis** *Oithona similis*, Nauplius and other larval stages.
Tomopteris.
*Ceratium tripos*.
Diatoms.
Solid matter * As in No. 1.

No. 10. Copepoda *** *Eurytemora velox*, *Eurytemora affinis* ***. Nauplius and other larval stages.
*Ceratium tripos*.
Solid matter ** As in No. 1, but greater part consisting of vegetable fibres.

# SOME OBSERVATIONS UPON THE CHEMICAL COMPOSITION AND THE POSSIBLE COMMERCIAL VALUE OF SEAWEEDS.

By HERBERT W. R. HASELHURST, B.Sc.

The published accounts of chemical observations upon seaweeds are not numerous. On the west coast of Scotland, in the Scilly Isles, and in some parts of Kent seaweed is largely used as a manure, and in 1898 Professor J. Hendrick, of Aberdeen University, published an account* of some analyses of seaweed, and gave the results of some field experiments in which it was used as a manure. Somewhat earlier than this, E. C. C. Stanford gave an account* of a substance, "Algin," obtained from seaweed; this, it was hoped, would have a commercial value. These two publications, along with certain analyses in works on agricultural chemistry, comprise the whole of the chemical literature upon the subject.

In Cullercoats Bay and on the neighbouring beaches many tons of drift weed are thrown up, more especially from the end of September to the beginning of April. At the request of Professor Meek I undertook to analyse chemically the seaweed at Cullercoats.

The material worked upon was taken from two localities, the first being the outcrop of magnesian limestone near the Ninety Fathom Dyke at Smuggler's Cave, and the second an outcrop of carboniferous sandstones to the north of Brown's Point. The seaweeds used were always fresh cut, and no drift weed whatever was used. The commoner seaweeds of this locality are *Laminaria digitata*, *Fucus serratus*, *Fucus nodosus* and *Fucus vesiculosus;* indeed, the two former weeds compose the greater part of the local drift weed, and for this reason were chosen as subjects for this investigation.

A fairly large quantity (50 grammes) of *Laminaria digitata* was incinerated and all organic matter thus got rid of. The ash was then analysed with the following result. Bases present in fair quantity were potassium, sodium, magnesium and calcium, whilst the acids identified were chloride, sulphate and phosphate. In five subsequent analyses iron in traces was recognised in three

* Journal of Highland and Agric. Soc. 1898.
*Chemical News, Vol. 47, pp. 254—267.

samples, while in the other two no iron was present at all. The ash from the incineration of a larger sample of the weed showed very small traces of iodine. Before incineration all adhering sand was removed, yet in the ash small quantities of silica were recognised. Qualitative analyses of the Fuci and *Laminaria saccharina* led to very similar results. Qualitative analyses of the organic portion of the seaweeds showed that cellulose formed the greater part of the tissue. It was noted that when Laminaria, especially, was allowed to stand in water, a thick mucilage was formed. Large "blisters" were formed on the fronds probably by endosmosis. These vesicles ultimately burst, and a gum-like material exuded. This at first was quite colourless, but later it became opaque, and a white scaly material was deposited on the sides and bottom of the containing vessel. This substance has been the subject of research by E. C. C. Stanford (loc. cit.), who has termed it "Algin." The tests given for "Algin" by Stanford were applied to the material, and many gave successful results. The majority of them, however, are admittedly tests for protein bodies, and the statements made by Stanford in his paper upon the subject show that the substance is a mixture. Thinking this I communicated with Dr. T. B. Osborne, of the Conn. Agric. Expt. Station, who is of the same opinion. "Algin," however (to retain Stanford's nomenclature), does contain one and probably a number of proteins, one of which is a vegetable globulin, for a solution of the same in a fairly dilute solution (10 per cent.) of ammonium sulphate responded to the following reactions—the Xanthoproteic, the Adamkiewicz and Molisch's Reaction. It is hoped shortly to bring forward the results of some further and more detailed observations upon this subject. Regarding the sugars present in algæ, the ozazones have been prepared from that contained in *Laminaria saccharina*, both in thin section of the plant, and from the extract of it with water after the precipitation of lixiviated salts; these are at present under examination. When *Laminaria digitata* was digested with sulphuric acid, the resulting liquid gave evidence of the presence of a sugar; probably this may have resulted from the hydrolysis of the cellulose present. An ozazone was prepared from this sugar, and its appearance under the microscope was remarkably like that of glucosazone. The brown colouring matter of the Fuci and Laminaria is phycophaein, and this may

be removed by boiling the plants in water, for the water becomes permanently brown. Having removed the phycophaein thus the green colour of the chlorophyll becomes apparent.

The results of the quantitative analyses of *Laminaria digitata* and *Fucus serratus* are given in the following tables :—

LAMINARIA DIGITATA.

| | | 1. | 2. | ✳ |
|---|---|---|---|---|
| A. | Water ... ... ... | 86·35 | 84·45 | |
| | Dry matter ... ... | 13·65 | 15·55 | |
| B. | Combustible matter ... | 62·69 | 64·18 | |
| | Ash ... ... ... ... | 37·31 | 35·82 | |
| C. | Phosphoric acid—$P_2O_5$ ... | 2·008 | 2·0185 | 0·95<br>1·11 mean = 0·98<br>0·88 |
| | Lime—CaO ... ... | 2·68 | 2·53 | |
| | Magnesia—MgO ... ... | 1·98 | 1·86 | |
| | Potash—$K_2O$ ... ... | 6·15 | 7·3 | |
| | Siliceous matter ... ... | 0·61 | 0·93 | |
| D. | Nitrogen ... ... ... | 3·16 | 2·83 | |

FUCUS SERRATUS.

| | | 3. | 4. | ✳ |
|---|---|---|---|---|
| A. | Water ... ... ... | 80·1 | 82·03 | |
| | Dry matter ... ... | 19·9 | 17·97 | |
| B. | Combustible matter ... | 73·46 | 76·17 | |
| | Ash ... ... ... ... | 26·54 | 23·83 | |
| C. | Phosphoric acid—$P_2O_5$ ... | 1·08 | 1·13 | 0·39<br>0·51 mean = 0·44<br>0·43 |
| | Lime—CaO ... ... | 2·23 | 2·26 | |
| | Magnesia—MgO ... ... | 1·45 | 1·40 | |
| | Potash—$K_2O$ ... ... | 5·48 | 4·99 | |
| | Siliceous matter ... ... | 0·22 | 0·20 | |
| D. | Nitrogen ... ... ... | 2·88 | 3·13 | |

The group A gives the results of the determinations of water and dry matter in the original weeds; B, the results of the estimation of combustible matter and ash in the dry matter; C shows the composition of the ash, the amounts being calculated as percentages of the dry matter; while D gives the nitrogen content. The analyses show that water constitutes on the average 83·24 per cent. of the growing plant. This, however, is no doubt higher than the actual water content of the seaweed, for the water was estimated immediately after the weed was cut, and adhering moisture was not removed. In the analyses of the ash variations are apparent, and though sometimes great, as in the case of nitrogen and potash, they are no greater than the variations in the amounts of certain constituents of land plants. The amounts given in the analyses of the ash are means of three estimations obtained with three different samples of the ash of the same seaweed. Samples 1, 2, 3 and 4 were taken from the Smuggler's Cave area, while the samples marked * were cut from the rocks to the north of Brown's Point. While conducting these analyses I compared my results with those obtained by Hendrick (loc. cit.) and Toms (Notes on Farm Chemistry), and found that the amounts of phosphoric acid present in the samples taken were much greater than those which they had found. Six samples were therefore taken, three of each kind, from the rocks at Brown's Point area, 700 yards to a half-mile to the north of the former locality. These samples grew on a carboniferous sandstone bottom, whereas in the other area they grew on a magnesian limestone bottom. After drying and incineration the amounts of phosphoric acid in these samples were determined. The three results for each of the two kinds are given in the column marked.* The difference in the phosphoric acid content is most marked. It seems that this is a remarkable example of environment upon the chemical composition of a sea plant. The composition of seaweed is largely, if not entirely, dependent upon that of the surrounding water. As the main current in this locality sets in from the north, the water of the Smuggler's Cave area does not pass the Brown's Point area; hence the salts dissolved (no matter how slowly) from the magnesian limestone would not have a chance of acting upon the seaweeds growing in the latter area, whereas those growing in the former area could

## HYDROIDS—*continued.*

STATION VIII.—17 miles S.E. by S. of THE CRUMSTONE.

| | June 27. | July 31. | Aug. 22. | Sept. 13. | Oct. 10. |
|---|---|---|---|---|---|
| *Podocoryne areolata* (Alder) ... ... | ** | | | ** | |
| *Dicoryne conferta*, Alder ... ... | **** | ** | | *** | |
| *Syncoryne* (sp. ?) *sarsii* (Lovén) ... | * | | | | |
| *Eudendrium ramosum* (Linn.) ... | ** | | | | |
| *Perigonimus repens* (Wright) ... | | | | ** | |
| *Tubularia coronata*, Abildg. ... ... | ** | * | | ****† | |
| *Campanularia raridentata*, Alder ... | 1 | | | 1 | |
| **Gonothyrea ? hyalina*, Hincks... ... | 1 | | | | |
| **Gonothyrea gracilis* (Sars) ... ... | * | | | | |
| **Obelia plicata*, Hincks... ... ... | *† | | | | |
| *Clytia johnstoni* (Alder) ... ... | ** | * | | 1 | |
| **Cuspidella grandis*, Hincks ... ... | 1 | ** | | * | |
| *Cuspidella humilis*, Hincks ... ... | * | * | | | |
| *Filellum serpens* (Hassall) ... ... | * | | | ** | |
| *Calycella syringa* (Linn.) ... ... | ** | *** | | *** | |
| *Lafoëa dumosa* (Fleming) ... ... | 1 | | No hydroids. | 1 | |
| *Lafoëa fruticosa*, Sars ... ... ... | **** | ** | | | |
| *Halecium halecinum* (Linn.) ... | 1 | | | | |
| *Halecium beanii*, Johnst. ... ... | 1 | 1 | | | |
| *Hydrallmania falcata* (Linn.)... ... | * | * | | * | |
| *Thuiaria thuja* (Linn.)... ... ... | * | * | | | |
| *Diphasia rosacea* (Linn.) ... ... | * | * | | | |
| *Diphasia tamarisca* (Linn.) ... ... | | | | * | |
| *Sertularia fusca*, Johnst. ... ... | * | | | | |
| *Sertularia argentea*, Ellis & Solander... | ** | * | | * | 2 |
| *Sertularia filicula*, Ellis & Solander ... | | | | * | |
| *Sertularella tenella*, Alder ... ... | ** | | | * | |
| *Sertularella polyzonias* (Linn.) ... | | | | * | |
| *Plumularia setacea* (Ellis) ... ... | * | | | 1 | |
| *Plumularia catharina*, Johnst. ... | * | ***† | | 1 | * |
| *Plumularia pinnata* (Linn.) ... ... | * | | | | |
| **Plumularia* (sp. ?) ... ... ... | 1 | | | | |
| *Antennularia antennina* (Linn.) ... | * | | | | |
| *Aglantha rosea* (Forbes) ... ... | | | | | ** |

* New to the district. † With reproductive capsules.

## HYDROIDS—*continued.*

### STATION IX.—4 miles E. by S. NEWBIGGIN.

| | May 13. | June 27. | July 31. | Aug. 22. | Sept. 12. | Oct. 9. |
|---|---|---|---|---|---|---|
| *Perigonimus repens* (Wright)... ... | | | **** | ** | | |
| *Dicoryne conferta*, Alder ... ... | | | ? | | | |
| *Campanularia ? raridentata*, Alder ... | | | | * | | * |
| **Campanulina turrita ?*, Hincks ... | | * | | | | |
| *Clytia johnstoni* (Alder) ... ... | | *** | * | ** | | |
| **Gonothyrea hyalina*, Hincks ... ... | | | * | | | |
| **Obelia plicata*, Hincks... ... ... | | * | * | | | |
| **Gonothyrea gracilis* (Sars) ... ... | | | | * | | |
| *Opercularella lacerata* (Johnst.) ... | | | | ** | | *** |
| *Calycella syringa* (Linn.) ... ... | | *** | ** | * | | |
| *Filellum serpens* (Hassall) ... ... | * | ** | * | | | **** |
| **Cuspidella grandis*, Hincks ... ... | | | * | | | |
| *Sertularia argentea*, Ellis and Solander | | | | * | | |
| *Sertularia cupressina*, Linn. ... ... | ****† | | | | | |
| *Sertularia abietina*, Linn. ... ... | | | * | | | |
| *Antennularia antennina* (Linn.) ... | | * | | | | |
| *Diphasia rosacea* (Linn.) ... ... | *** | | **† | | | |
| **Diphasia pinnata* (Pallas) ... ... | | | | | | 1 piece |
| *Plumularia setacea* (Ellis) ... ... | | | | | | * |
| *Plumularia echinulata*, Lamarck ... | | | stalk | * | | |
| *Thuiaria thuja* (Linn.) ... ... | | | | | | * |
| *Hydrallmania falcata* (Linn.)... ... | | | | ** | | |
| *Aglantha rosea* (Forbes) ... ... | | | | | | ** |

### CULLERCOATS.—8 miles E. by S.

30 faths. E.

| | Sept. 22, 1911. | July 9, 1912. | Sept. 17, 1912. |
|---|---|---|---|
| *Hydractinia echinata* (Fleming) ... ... | * | | |
| *Podocoryne areolata* (Alder) ... ... ... | * | *** | ** |
| *Dicoryne conferta*, Alder ... ... ... | * | *** | |
| *Perigonimus repens* (Wright)... ... ... | | | ** |
| *Tubularia coronata*, Abildg. ... ... ... | | *** | stalks |
| *Campanularia verticillata* (Linn.) ... ... | * | | |
| **Gonothyrea ? hyalina*, Hincks... ... ... | | * | |
| **Gonothyrea gracilis* (Sars) ... ... ... | *† | | |
| *Obelia dichtoma* (Linn.) ... ... ... | *† | | |
| **Obelia* (? sp.) *flabellata*, Hincks ... ... | * | | |
| *Filellum serpens* (Hassall) ... ... ... | | | * |
| *Lafoëa dumosa* (Fleming) ... ... ... | * | | * |
| *Halecium halecinum* (Linn.) ... ... ... | | ** | **† |
| *Hydrallmania falcata* (Linn.)... ... ... | * | | |
| *Sertularia abietina*, Linn. ... ... ... | * | | |
| *Plumularia echinulata*, Lamarck ... ... | * | | |

* New to the district. † With reproductive capsules.

## HYDROIDS—*continued.*

2½-3 miles E. of DUNSTANBOROUGH. July 31st; gravelly bottom.

| | |
|---|---|
| *Eudendrium* stalks ... ... ... ... ... | **** |
| *Dicoryne conferta* (Alder) ... ... ... ... | * |
| *Tubularia indivisa*, Linn. ... ... ... ... | *** |
| *Clytia johnstoni* (Alder) ... ... ... ... | * |
| *Campanularia volubilis* (Linn.) ... ... ... | ** |
| **Obelia plicata*, Hincks ... ... ... ... ... | **** |
| *Obelia dichotoma* (Linn.) ... ... ... ... | * |
| *Opercularella lacerata* (Johnston) ... ... ... | * |
| *Lafoëa fruticosa*, Sars ... ... ... ... ... | * |
| *Filellum serpens* (Hassall) ... ... ... ... | * |
| *Calycella syringa* (Linn.) ... ... ... ... | **** |
| *Thuiaria thuja* (Linn.) ... ... ... ... ... | * |
| *Sertularia argentea*, Ellis and Solander ... ... | ** |
| *Sertularia abietina*, Linn. ... ... ... ... | * |
| *Hydrallmania falcata* (Linn.) ... ... ... ... | ** |
| *Plumularia catharina*, Johnst. | |
| *Plumularia echinulata*, Lamarck. | |

E. of HOWICK BURN, 17 fathoms; rocky bottom.

May 12th.

| | |
|---|---|
| *Alcyonium digitatum* ... ... ... ... ... | *** |
| *Eudendrium ramosum* (Linn.) ... ... ... | * |
| *Campanularia flexuosa*, Hincks ... ... ... | *present* |
| *Clytia johnstoni* (Alder) ... ... ... ... | *present* |
| **Gonothyrea ? hyalina*, Hincks ... ... ... ... | ** |
| *Halecium tenellum*, Hincks ... ... ... ... | * |
| *Thuiaria thuja* (Linn.) ... ... ... ... ... | 2 |
| *Hydrallmania falcata* (Linn.) ... ... ... ... | 1 |
| *Diphasia rosacea* (Linn.) ... ... ... ... | * |
| *Plumularia catharina*, Johnst. ... ... ... | * |

CULLERCOATS HAVEN.—February 8th, 1912.

Very small pieces of :—

*Eudendrium* (stalks); *Obelia geniculata* (Linn.); *Calycella syringa* (Linn.); *Sertularia argentea* (Ellis and Solander); *Sertularella rugosa* (Linn.); *Thuiaria thuja* (Linn.); *Antennularia antennina* (Linn.).

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* New to the district.

# THE SPAWNING OF THE WHITING.

By B. STORROW.

In previous reports short accounts have appeared of the spawning of the cod and plaice, and figures have been given showing the stages in development for each day from spawning to hatching.

In August of last year some 19 whiting were caught on a line in the vicinity of Cullercoats Bay. Three of them died from injuries but the others are still living, and during April and May of this year yielded a considerable number of eggs, so many that it was necessary from time to time to place quantities in the sea in order that the eggs would not die from overcrowding. Every year similarly the eggs and larvæ which occur in the plaice tank are placed in the sea in the vicinity of Cullercoats.

The first eggs appeared on the 14th of March, but were not fertilised. On the 14th of April first and third day eggs were found in the tank, and from then to the 23rd of May first day eggs were present every day. Eggs of this stage occurred in numbers to the 8th of May, from then to the 14th only small numbers were spawned daily; from the 14th to the 19th they were again plentiful, and afterwards to the 23rd very few newly spawned eggs were observed.

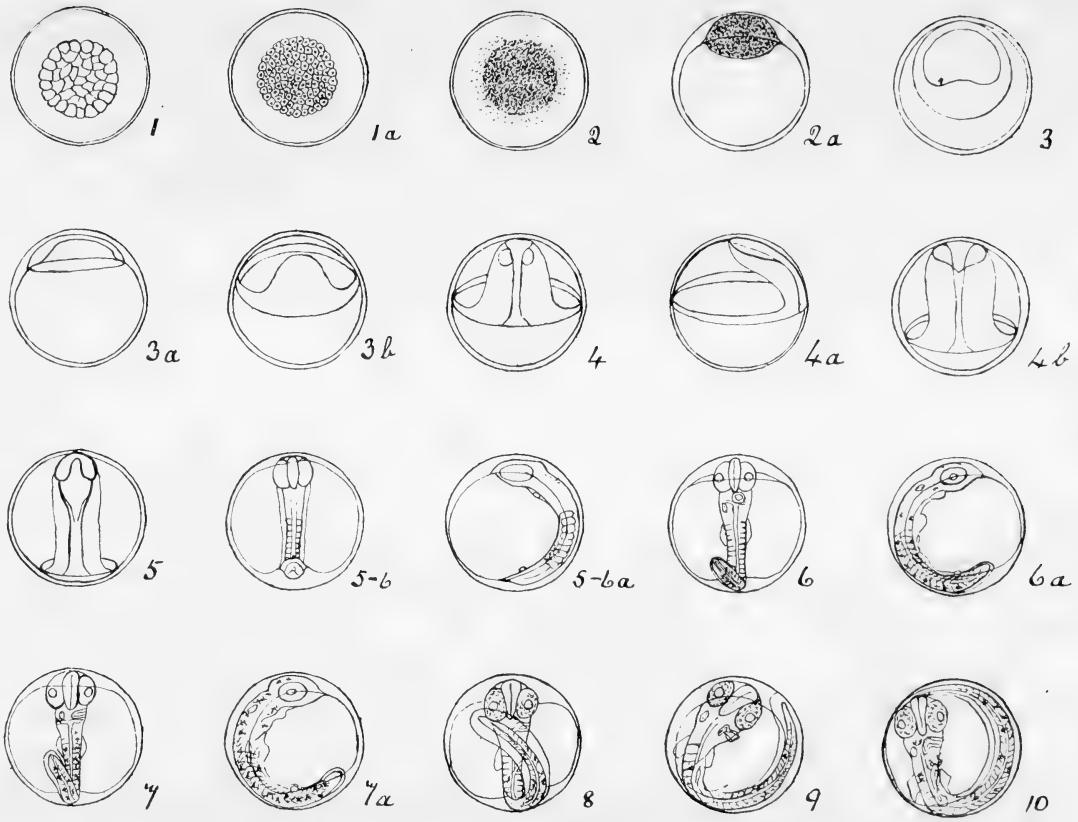
As a rule spawning took place in the morning, but occasionally later in the day, at odd times about noon, and once as late as 3 p.m.

The diameter of the eggs varied from 1·09 to 1·15 mm.

Samples of eggs were isolated in order to determine the period between spawning and hatching, and as in the case of the plaice this was found to vary. Eggs spawned on the 19th of April hatched on the 28th, the tenth day from spawning; the mean temperature of the water for this period was 9·1° C. Others spawned on the 23rd and 30th of April and on the 7th of May, hatched on the 1st, 8th and 15th of May respectively, the ninth day from spawning; the mean temperatures of the water for these periods were 9·5° C., 9·8° C. and 9·2° C.

The whiting were measured in the beginning of July, and the sizes were as follows ;—32 cm.-2, 30 cm.-4, 29 cm.-4, 28 cm.-1, 27 cm.-1, 26 cm.-1, 24 cm.-3.

The periodicity observed in the spawning of cod and plaice, and commented upon in previous reports, was also found in the case of the whiting, but owing to the number of fish in the tank it was to a large extent disguised.




STAGES IN THE DEVELOPMENT OF THE WHITING.

(The figures refer to the days from spawning).

# THE ORGANISATION OF THE TELEOSTEAN EGG.

BY ALEXANDER MEEK.

This is a preliminary paper. It is meant to serve as an introduction to a fuller account with especial reference to the embryology of the cod, which I hope to be able to publish by-and-by.

Notwithstanding the vast amount of work which has been done on the development of the Teleostei, the meaning of the processes leading to the establishment of the germ layers continues to be obscure. A tentative nomenclature has been found to be necessary, but no one is satisfied with any of the theories which have been advanced to explain the "blastodisc" and the "subgerminal" and "peripheral periblast." A fresh exploration of the facts is therefore called for.

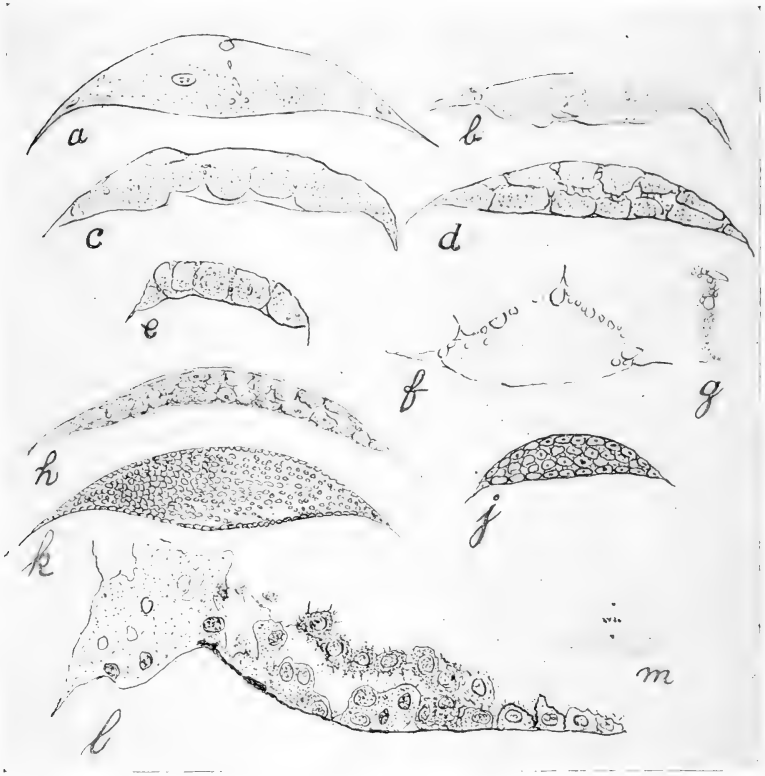
THE FERTILISED OVUM.—Apart from the capsule, the origin and nature of which I am not at present to discuss, the relatively small meroblastic ovum of pelagic Teleostei consists of a nucleus near the animal pole, surrounded by a conspicuous polar mass of cytoplasm, sharply marked off from the rest of the cytoplasm which is distended by the yolk. The polar cytoplasm is continued around the yolk as a fine pellicle, the peripheral protoplasm, and both the polar and peripheral protoplasm are continued by fine strands of protoplasm into the yolk, where a network of protoplasm is formed. The network may be seen at all stages of segmentation, and also minute swellings or knots which increase in size peripherally. The latter point to a continuation of the process of streaming which has led to the conspicuous differentiation of the yolk and the protoplasm. The process of streaming was carefully described by Ransom * and by Kowalswsky † for fresh water fish, and by Ryder ‡ and by Agassiz and Whitman || for pelagic sea fish. The result of the streaming is not merely to produce the obvious polar mass and the peripheral layer of protoplasm, but, as will be seen, to orientate both definitely with respect to the structures which are to arise from them.

* 1867, Phil. Trans. Roy. Soc., v., 157.
† 1886, Zeit. f. wiss. Zool., Bd. 43.
‡ 1885, Rep. Fish. Comm., U.S.
|| 1889, Mem. of the Mus. of Comp. Zool., Harvard, iv., 14.

Primitively, all ova have such an interlacing protoplasmic network culminating in a superficial sheet. In the case of holoblastic eggs this structure is retained. In the egg of the lamprey, for example, the interlacing or vacuolated cytoplasm may be easily traced from the clear space around the nucleus into the region beyond, which is thickly beset with oval yolk granules, and also into the peripheral layer. This is also evident from the figures and description of Herfort.* How far the primitive protoplasm of the yolk in meroblastic eggs is retained is not yet quite clear, but in the neighbourhood of the nucleus it is certainly present, and can be followed into the yolk, and it also forms a superficial layer. A preparation I possess of a fully developed egg of Acanthias from the ovary shows both these features. In meroblastic eggs a so-called periblastic extension of the protoplasm outwith the segmentation area is a recognition of the existence of the peripheral layer of protoplasm. The presence of such a layer and of fine strands of protoplasm amongst the yolk granules of such large meroblastic eggs as those of reptiles and birds has been described by Waldeyer,† Sarasin‡ and His.‖ It has still to be determined whether the streaming of the protoplasm towards the animal pole of such large meroblastic eggs removes the protoplasm entirely from the vegetal region of the egg or reduces the strands to such a degree of tenuity as to make them difficult to follow.

Segmentation.—The description of the segmentation of the egg of the Teleosteans given by Agassiz and Whitman § is exactly that which I have observed in the case of pelagic Teleostei. The procedure, as these authors stated, is subject to modification. There is one feature which these authors certainly saw and which led later to some extent to Whitman's paper on the "Inadequacy of the Cell Theory,"** but which does not appear to have received the attention it deserves—the remarkable and yet evidently general method of cleavage.†† The cells are not completely separated from one another. After the nuclei have separated vacuoles appear in the region previously occupied by the equator of the spindle, and these are added to so as to bring about a line of demarcation between the cells, but which, nevertheless, remain connected by at first thick laminæ and latterly by thin protoplasmic bridges.

* 1893, Anat. Anz., Bd. 8. 1900, Arch. f. Anat. u. Entw.-ges., Bd. 57.
† 1870, Eierstock u. Ei. 1906, Hertwig's Handb. d. Entw. d. Wirbeltiere, Bd. 1.
‡ 1883, Inaug. Diss. ‖ 1900, Histog. Studien. § *Loc. cit.*
** 1893, Wood's Hole. Lectures. Also 1894, Jour. of Morph., v., 9.
†† See also Brook, Proc. Roy. Phys. Soc., Edin., 1886.




TELEOSTEAN EGG.—Fig. 1.

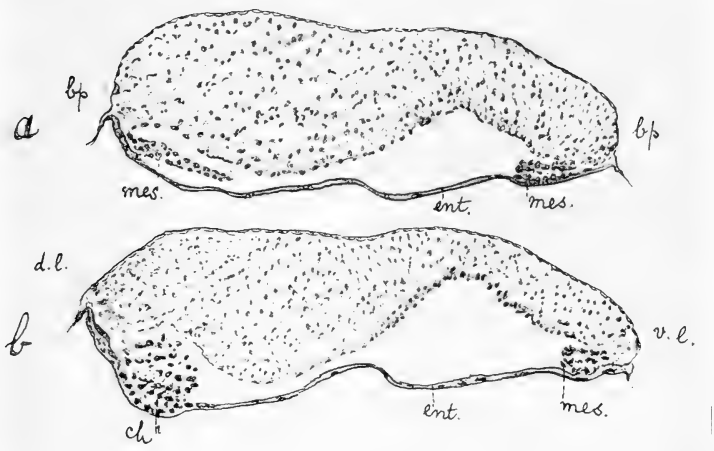
PLATE I.

Figs. f, g, l, m × 450; rest × 50.

The sections in this and the following figures have been drawn with the help of the Leitz Drawing Apparatus.

PLAICE—(*a*) 4-cell stage; (*b*/*c*) 12-cell stage; (*d*/*h*/*k*) successive segmentation stages during the 1st and in the case of (*k*) the 2nd day.

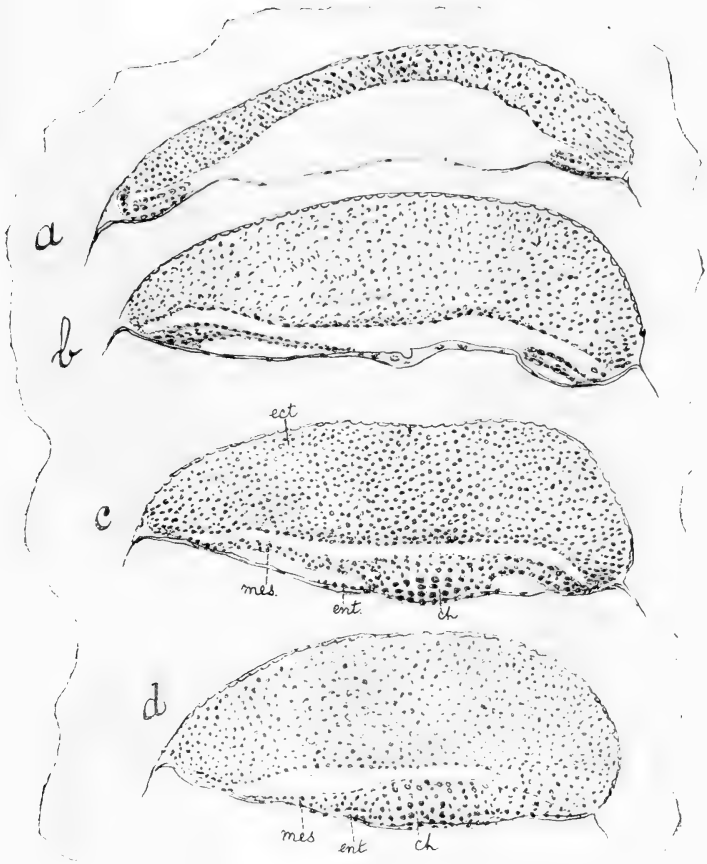
COD—(*e*/*j*) segmentation stages at beginning and end of 1st day; (*f*/*g*) indicate the development of vacuoles between adjacent cells; (*l*) margin and adjoining ventral portions of blastodisc at end of 2nd day; (*m*) vertical division of cell in lower layer, end of 2nd day.




TELEOSTEAN EGG.—Fig. 3 × 97.

PLATE III.

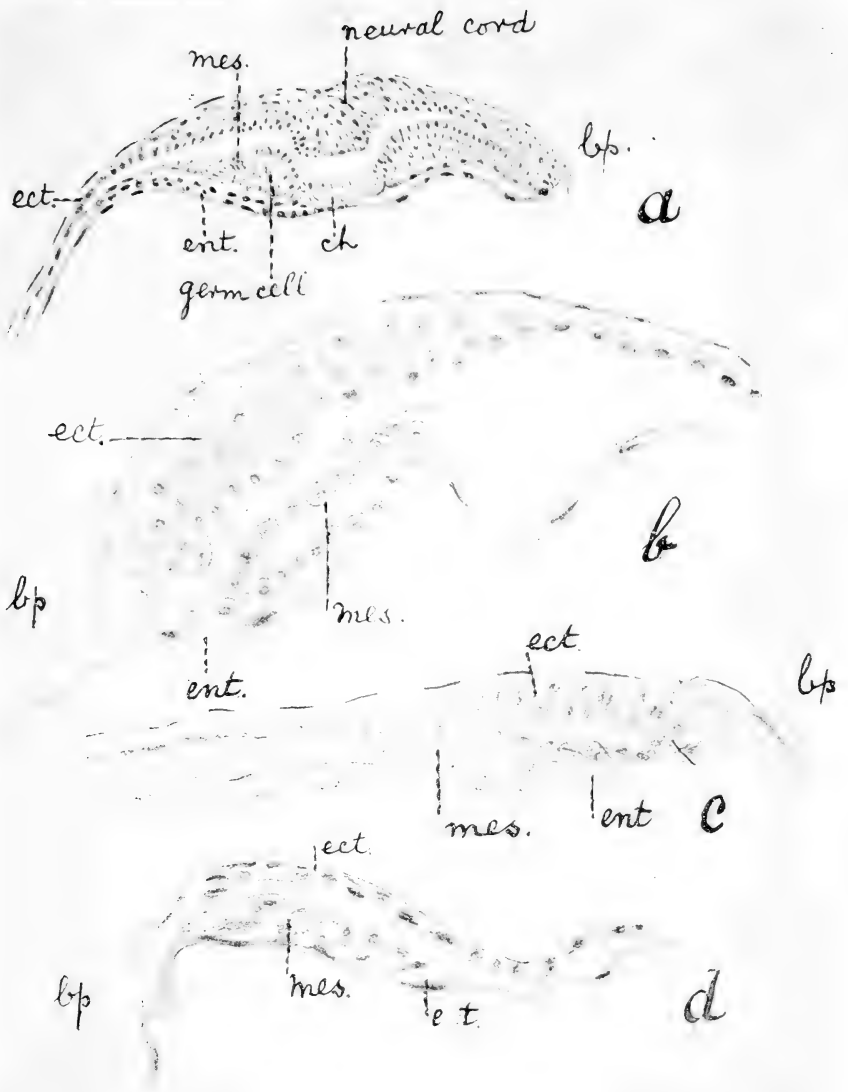
Two obliquely sagittal sections of an early 3rd day Cod; (*a*) to one side of the notochord; (*b*) medianly through the notochord.




TELEOSTEAN EGG.—Fig. 4 × 97.

PLATE IV.

A series of transverse sections of an early 3rd day Cod,—see text.




TELEOSTEAN EGG.—Fig. 5.

PLATE V.

Fig. a × 135; b, c, d × 450.

COD—(*a*) obliquely transverse section near the posterior end of a 4th day embryo; (*b*/*c*/*d*) the ventral lip of the blastopore of embryos of 3rd, 4th and 5th days respectively.

At the period of the appearance of the first and second meridional divisions of the egg the resulting blastomeres appear to be separated in the living egg by complete furrows. Sections show, however, that the line of separation is brought about by vacuoles appearing in the plane of the furrow. Figure 1*a* is a drawing of a section of a 4-cell stage of the plaice, and indicates the early condition of the vacuoles. Their small number and relatively large size during the early stages are likewise evident from figs. 1*b* and 1*c*. It may also be noted that the vacuoles do not open to the surface, nor do they pierce a similar film of cytoplasm which separates the blastomeres from the yolk.

The subsequent fate of the vacuoles will be evident from figs. 1*f*, *g* and *l*. In the case of fig. 1*c* an appearance is produced which is reminiscent of the well-known figures of Agassiz and Whitman. A thin layer of protoplasm is seen stretching from the marginal cells below the central cells. This is due to the fact, however, that the drawing has been made from a section near to the plane of separation of these cells from their neighbours. The vacuoles next the yolk extend under the blastomeres incompletely separating the blastomeres from a layer of cytoplasm which thus becomes better defined. Similarly the vacuoles expand under the superficial layer of cytoplasm so as incompletely to separate that layer from the blastomeres below it (figs. 1*d* and 1*h*). When segmentation has proceeded so far as to bring about two layers of blastomeres, as shown by those figures, the upper layer is attached to a thin covering layer of protoplasm ; the lower layer is similarly related to a thin protoplasmic sheet which lies between it and the yolk. The blastomeres, however, of both layers are intimately connected with one another laterally and vertically by protoplasmic bridges.

The continued fragmentation of the nuclei leads to the development of a large number of blastomeres in the polar mass of protoplasm, the blastodisc of authors. During the process in the case of the cod and whiting, to a less extent in the case of the plaice, the space occupied by the blastomeres becomes deeper and at the same time narrower. Measurements show that the contraction in the blastodisc of the egg of the whiting is about ·09 mm. (*cf.* fig. 2*a*, page 84). A comparison of figs. 1*a* and 1*k*, which are drawn under the same power, will serve to indicate how little the blastodisc has changed during the process of segmentation in the plaice. The protoplasm of the area is moreover perfectly continuous. All the

blastomeres are connected as stated and with the limiting layers of cytoplasm already referred to. These two layers are continued marginally into the investing protoplasm of the yolk—the so-called periblast—which latter like the ventral sheet of the blastodisc is connected to the protoplasmic network of the yolk.

This picture of the conversion of the polar mass of cytoplasm into the nuclear area with imperfectly separated cell masses of cytoplasm around each nucleus recalls the considerations raised by the late Prof. Sedgwick * from his study of the development of Peripatus. Haidenhain † has also drawn attention again to the intimate association of the cells of tissues by protoplasmic connections. I find the same method of division occurs in the lamprey, in Lepidosteus and in Amia, and also in the fowl and in the gull.

Gastrulation.—So far the account I have given will be found to agree with the descriptions of the processes of segmentation of most of my predecessors. The only important difference is that the sub-blastodisc sheet of protoplasm—the so-called sub-germinal periblast—is not separated from the blastomeres as described by Agassiz and Whitman.‡ I now come to the consideration of the changes which follow segmentation, which are to some extent dovetailed into the process of segmentation, and which have given rise to a host of theories. It will be found that the facts are even more strange than the theories.

First, with regard to the cells at the margin. It has long been known that during the latter part of the segmentation phase nuclei appear in the marginal protoplasm of the blastodisc where the latter merges in the peripheral protoplasm (fig. 1*l*). These nuclei arise in the ventral part of the series of single marginal cells, and only differ from the other nuclei of the blastodisc in not leading to such distinct vacuolation of the surrounding cytoplasm. Vacuoles are developed, however, in this marginal syncytium, serving particularly to separate the outer non-nucleated protoplasm of the margin from the lower nucleated portion. *Pari passu* with the fragmentation internal to them the nuclei of the margin divide. The nucleus elongates, and two nuclei arise by constriction. In some cases at least an appearance is met with which points to chromatin segregation, but a distinct spindle is not formed.

* 1886, Q.J.M.S., v., 26. † Plasma und Zelle.
‡ *Loc. cit.*

The syncytial influence, towards the end of the second day that is towards the end of the segmentation period, extends to the sheet of protoplasm next the margin on the ventral side of the blastodisc. This appears always to occur by a number, not all, of the cells of the blastodisc which are attached to this layer dividing vertically (fig. 1*m*) the ventral of the resulting cells sinking into and merging with the protoplasmic sheet which thus becomes thickened, the other remaining connected with the cells around it. Early in the third day the same process takes place over the whole of the ventral protoplasmic sheet of the blastodisc, converting the whole of this into a syncytial layer continuous with the marginal syncytium. I have looked carefully over a great many preparations of the stages concerned of the cod, whiting and plaice, and I cannot find the least trace of an inwandering of the marginal nuclei into the sub-germinal periblast as described by Agassiz and Whitman. In the case of the plaice the marginal cells retain their individuality longer than in gadoids, and the change described takes place almost simultaneously over the whole of the sub-germinal periblast. Inferentially then an invasion of this area by marginal nuclei is impossible.

This is followed by a change of the greatest importance. The prelude to it is the increase in number of, and the fusion of the vacuoles of the marginal syncytium, dividing definitely an ectoplasm continuous with that to which the outer layer of blastomeres is firmly connected (fig. 2*a*) from an entoplasm in which the marginal nuclei are embedded, and which is continuous with the ventral sheet of protoplasm of the blastodisc. Then the whole blastodisc becomes gradually flattened, the margin at the same time advancing over the yolk. The blastomeres near the margin press into the excavated region external to them, and the lower syncytial layer next the yolk becomes defined by the withdrawal of the cells above it. A cavity is thus formed, which becomes more and more apparent as the protoplasmic strands are absorbed.

By these processes the blastodisc has become resolved into a many-layered ectoderm, and a syncytial entoderm united at their margins. The outer protoplasmic sheet is still present, and the outer layer of ectodermal cells now flattened is closely applied to it. The entoderm is based on the primitive protoplasmic sheet next the yolk, and now consists of a thickened sheet of protoplasm

with scattered nuclei. These two layers as at first are continued into the peripheral protoplasm of the yolk. All round the margin it will be seen from the figures that certain of the cells may be identified as ectodermal, that below these are cells which gradually merge in the syncytial entoderm.

With the exception then of the syncytial change in the entoderm and the similar change beginning to take place in the external layer of the ectoderm, we have here a gastrula consisting of an ectoderm and an entoderm united at the margin of the widely distended blastopore. The entoderm therefore is formed by delamination. It is interesting to note, furthermore, that whether deliberately or from the fate of position the foundations of the layer were laid down before segmentation started, in the sheet of protoplasm which at first was indistinguishable from the rest of the blastodisc.

The failure to recognise in this so-called sub-germinal periblast the virtual gastrula entoderm has led to most of the misunderstandings with regard to Teleostean development. The proofs that it is really the entoderm will now be given.

The Postgastrula.—As soon as the changes which have been described have occurred the gastrula passes into the postgastrula stage, and a bilateral appearance becomes evident by the broadening and deepening of the rim over an area which marks the dorsal lip of the blastopore (*see* fig. 3, page 84). At the same time, the cavity above referred to becomes more plain by the thinning of the roof. This is brought about by the ectodermal cells of the region lengthening vertically and being drawn up between one another. The anterior end of the brain becomes by the process gradually more and more distinct (fig. 3).

It is plain also that the anterior end of the brain originates in the gastrula, and already presents an infundibular mass which thins out on each side. The outer layer of ectoderm is now very thin, the cells having become flattened and incorporated with the original superficial layer of protoplasm. At the margin this layer of protoplasm merges into the peripheral protoplasm of the yolk, where it is joined by the syncytial entoderm. The latter is now entirely free from the ectodermal cells, and at the margin it is concerned medianly in the formation of the notochord and laterally with the formation of the marginal mesoderm. In both cases

certain of the indifferent cells of the margin participate in the formation. The only difference is that at this period the notochord remains connected with the entoderm, the mesoderm early loses its connection with the entoderm except at the place of origin. By this change there are interposed between the ectoderm and the entoderm at the growing margin a median notochord, continuous on each side with wings of mesoderm which extend all round the margin. In point of origin the notochord and the mesoderm are the same. This serves still further to emphasise the cavity above referred to. It is a " mesoderm-free " area, and marks as it possibly always does the region of the primitive gastrula.

This will be still more plain from a consideration of the transverse sections of a slightly older embryo (fig. 4). The figures are drawn from sections (*a*) through the mesoderm-free area in front of the brain, (*b*) immediately in front of the notochord, (*c*) and (*d*) through the anterior and posterior ends of the as yet short notochord. It will be at once apparent to those familiar with the subject that, apart from the syncytial condition of the entoderm and the massiveness of the ectoderm, the sections bear a remarkable resemblance to those obtained from similar stages of Selachii. The median notochord is formed from a proliferation of entodermal cells, syncytial though they be, but as has been seen from fig. 3*b* the structure is contributed to also from the marginal cells. On each side of the notochord for a short distance—and altogether independently of the marginal cells—a proliferating area is developed in the syncytial entoderm, which gives rise to the enteron entoderm. The notochord passes insensibly into the marginal mesoderm, which, as has been seen, has a similar origin, viz., from the syncytial entoderm and from the marginal cells. It cannot truly be said here at all events that the mesoderm is divided into an axial and a marginal. Both have the same origin in the margin, and so has the notochord. The notochord may therefore be regarded as *the* axial mesoderm. This is not a new suggestion, but it is the first time it has been so clearly indicated from embryological work. If the above explanation of the origin of the notochord be considered to be sufficient, then it will no longer be necessary, for example, to refer chorda cartilage to ectoderm or to entoderm.

A layer, even though it is syncytial, which encloses the yolk, furnishes entirely the embryonic entoderm, and yields to such a large extent the notochord and mesoderm can only be the entoderm.

I do not propose here to bring into review the many theories which have been proposed with regard to the above processes of Teleostean development. As has already been said, most have arisen from the failure to recognise the true importance of the entoderm, the existence of which was either ignored or wrongly interpreted. It cannot be said either that the entoderm does not take part in the formation of the embryo, since it yields the entoderm of the embryo and participates to such a large extent in the formation of the notochord and the mesoderm.

The Peripheral Protoplasm of the Yolk.—The next point to which I wish to direct attention is the fate of the peripheral protoplasm of the yolk. Notwithstanding the fact that in the sections we have just been considering of third day embryos, the embryonic area has extended to about a third of the superficial area of the egg, the margin has still the same structure as before. The outer layer of ectoderm is continued into the protoplasmic sheet which enwraps the yolk. The syncytial entoderm runs similarly into the peripheral protoplasm, and just before the two layers join they are connected by protoplasmic bands. The whole margin presents the same structure. The figs. 5*a-d* will show that during the subsequent stages when the yolk is being surrounded by the blastoporal growth the margin has still the same structure. In the case of figs. 5*a* and 5*c* (*see* fig. 4, page 84) the margin occupies the equatorial region of the egg, and in fig. 5*d* (*see* fig. 5, page 84) the lips are being approximated at the vegetal pole. In each case it will be seen that the margin is proliferating ectoderm, entoderm and mesoderm, and that the investing cytoplasm of the yolk is progressively divided into an outer and an inner layer connected by strands of intervening protoplasm. It is clear also that the outer layer is continuous all the time with the outer ectodermal layer, and the inner with the entoderm. There is no difference in this respect at any stage in any part of the margin. In other words, the peripheral protoplasm of the yolk is not lost; it is progressively excavated, and the resulting sheets of protoplasm form the bases of or are incorporated with the outer layer of ectoderm and the syncytial entoderm. It has already been shown that the polar mass of protoplasm is resolved during segmentation into an outer ectoderm and an inner entoderm. This is clearly also the case with regard to the peripheral protoplasm of the yolk.

We have so long been accustomed to the conception that the egg consists of an upper ectodermal region and a lower entodermal region that this comes to some extent as a surprise. The peripheral layer of protoplasm is present also in the eggs of Selachii, other Meroblastica and in Mammalia. But further work is necessary with regard to these, and even in the case of Holoblastica before a general statement can be made as to the nature and importance of the layer.

The Organisation of the Teleostean Egg.—The foregoing has already indicated the main features of the organisation of the Teleostean egg. The protoplasm is arranged by a streaming process into a polar mass containing the nucleus, a peripheral layer, and a reticulum containing the greater quantity of the yolk. Development shows that the latter, together with a thin film of protoplasm around it, forms the basis of the entoderm of the embryo and of the yolk sac. The rest of the protoplasm of the polar cap and of the peripheral layer forms the ectoderm. The nuclei necessarily are confined primarily to the polar mass, and secondarily by the multiplication at the blastoporal margin invade the region of the peripheral protoplasm, converting the latter into ectoderm and entoderm.

The polar mass is only resolved into ectoderm and entoderm. At the margin when the growth of the blastopore commences, and outwith the area of the polar mass, the notochord and mesoderm are developed between the ectoderm and entoderm. The polar mass is therefore a mesoderm-free area, which by the separation of the ectoderm and entoderm presents a cavity—which may be called a segmentation cavity—although a discussion of the morphological features of this cavity is not called for here.

It will be plain from the above and a consideration of the diagrams illustrating the development of the whiting (page 84) that the margin of the blastopore is resolved into a median (dorsal) region, the structures of which enter into the formation of the embryo proper, the rest being concerned in enveloping the yolk. The ectoderm of the latter is part and parcel of the ectoderm of the embryo, the entoderm forms the entoderm of the yolk sac, and is finally absorbed with the yolk.

It is more than likely, though I have taken no means to find out, that the median plane of the embryo coincides with the plane of the first division of the ovum nucleus. But as will be seen from the figures accompanying this paper, it is certainly incorrect to speak of the next cleavage dividing the embryo anteriorly and posteriorly. If the position of the first plane be granted, the second one marks rather the anterior end of the embryo or the position of the head fold from which the stomodeum arises.

The region of the polar cap which is to become ectoderm, and that which is to be entoderm, can be identified in the fertilised egg before segmentation begins. It might be affirmed therefore that with respect to this region these two layers are pre-determined in the cytoplasm. Not only so, but that the whole area is made up of " Bezirke " or regions forming a mosaic and pre-localised as to the origin of particular organs. If this be true it must include likewise a small region on each side of the mid-dorsal line similarly pre-determined to form a germ cell. Viewed in this way the polar mass of cytoplasm is pre-localised only with regard to structures which enter into the formation of the anterior end of the head. For it is clear that during gastrulation the " Keimbezirke " give place to " Randbezirke." Can it be said that in addition to a pre-determination of the elements forming the margin of the blastopore the peripheral protoplasm which is incorporated during the growth of the margin is also pre-localised with respect to the organs into which it may enter ? I have not Kopsch's * paper by me, but so far as I remember his experiments do not refer to the peripheral protoplasm. But one is almost justified in assuming that an injury to this layer would not have more than a mechanical effect upon the growth of the postgastrula. If it be the fact that the mid plane of the embryo is, for example, also pre-determined in the peripheral layer a re-statement will be necessary with regard to the growth of the dorsal lip in embryos in which this layer has not yet been described. There is nothing to be seen in the layer which would lead one to say that in the dorsal region the layer would be separated by the elements entering into the formation of the embryo proper, and on the other side separated only by mesenchyme. I venture to think therefore that we must accord to the peripheral cytoplasm

* 1904, Unters. Gastr. u. Embryob.

a passive role, and that any pre-determination that may be present is confined to the margin of the blastopore. If this be so, then we may ascribe the destination of the cytoplasm of this part of the egg to the " fate of position." *

Even with regard to the polar mass of cytoplasm we have to recall that the chief factor in its formation is the flowing of protoplasm to the animal pole. This is accompanied by the migration of the nucleus, is particularly evident during the maturation phases of the nucleus, and reaches its highest degree of intensity during the entrance and fusion of the spermatozoon. Were our predecessors wrong after all in ascribing the determination of the animal pole and the position taken up by the centrospheres to the nucleus ? If these are localised in the nucleus there is no need to look further for evidences of localisation.

In spite of the vast amount of work which has already been done on this subject, the result of which has been to give a high degree of importance to the cytoplasm, I am led by a consideration of the meroblastic eggs of Teleostei to the conclusion that the orientation of the egg is a function of the nucleus.

* 1897, Meek, Post-Embryonal Development.—*The Veterinarian.*

# COMPRESSED AIR INSTALLATION AT THE MARINE LABORATORY.

By LIONEL WOOD.

In order to provide means for suitably aerating the tanks and dishes throughout the Laboratory, an air-compressing installation was fitted during the spring of this year.

Considerable difficulty was originally encountered, it being apparently impossible to obtain satisfactory and trustworthy data as to the aeration of tanks, and it was found necessary to attack the problem from first principles. All the installations about which information could be obtained appeared to require a two horse-power compressor to raise the pressure of the air to about five atmospheres ; the air being then taken to small storage cylinders from which it passed through a reducing valve at about 0·4 or less of an atmosphere to tanks in the buildings. In this particular instance it was considered that the running and capital cost of such an installation would be too high, and an attempt was made to do the work in a more efficient and economical manner without sacrificing reliability.

The aspirator principle was the original method adopted of aerating the water in the main aquarium, effected by leading a fine jet of water into a glass tube extending to the bottom of the tank. The jet, as it impinged on the water in the tube, imprisoned large quantities of air, carrying it down to the bottom of the tube, where it arose in the form of minute bubbles. Air broken up in this way presented a maximum surface to the water, and effected a solution in the most rapid manner. At the same time, a considerable current was set up in the tank, due to the air displacement.

As this method of aerating by means of extremely fine bubbles proved so satisfactory in the original scheme, trials were made to reproduce the same results by means of compressed air. A small nozzle, about $\frac{1}{2}$ inch diameter, capable of use with various substances, was connected to a hand air pump and receiver. The nozzle was lowered to the bottom of the tank and air passed through it, the pressure being measured on a gauge. Numerous substances

were tested, such as earthenware filter diaphragms, asbestos cloth, pumice stone, bolting silk, muslin, &c., &c., and it was found that the best result was obtained by using three layers of bolting silk, which broke up the air in a highly satisfactory manner when the pressure was properly regulated. It was decided, however, not to use this at first, as it was considered that it would not completely withstand the action of sea-water, and in the end cane was chosen, though it is by no means a thoroughly satisfactory medium owing to the great variation in its porosity. Experiments are being made with other materials, such as elm, which already has been found to give promising results.

The final nozzles were made about $1\frac{1}{4}$ inches in diameter, and of sufficient length to take a piece of cane about $1\frac{1}{2}$ inches long, with suitable arrangements for replacing the cane by discs of various material in carrying out further experiments later.

These special nozzles were used only in the case of the deep tanks in the main aquarium, as they are not suitable for the shallow tanks in the workers' aquarium, or the various dishes in the private laboratories. In the two latter cases the best results so far have been obtained by sealing one end of a rubber tube which has been punctured by a needle at several points for a length of about 4 inches. Fine bubbles in large quantities and over a considerable extent are thereby produced, effectively aerating a shallow tank.

With reference to the compressor, it was decided to compress the air to the precise degree required, and run the installation continuously day and night with a view to the greatest economy. A special form of rotary compressor was adopted, driven by an electric motor, automatically increasing in speed to meet a greater demand for air. By this means the apparatus is comparatively self regulating, though a bye-pass relief valve was fitted so that any excess of air should be released and returned to the suction side of the compressor. Besides this automatic regulation and bye-pass valve, a suitable regulating switch was installed to bring the speed of the blower down to the minimum requirements in order that, with only a few tanks at work, both consumption of current and wear and tear on the compressor might be reduced. The maximum pressure required in any of the tanks was found to be 2 lbs., due to the head of water against which the air had to be forced. It was therefore decided to make an allowance for back pressure on the

diaphragms and friction in the piping, and to employ a pressure of 4 lbs. to the square inch. The compressor is placed on a bracket fixed to the wall of the pump room outside the laboratory; the suction pipe being led through the pump room wall to a sheltered place underneath one of the main water storage tanks where a suitable filter is fixed. Both suction and delivery pipes have a short length of rubber hose inserted to prevent the transmission of sound, and the compressor itself is placed on a sheet of rubber.

Delivery pipes are taken from the compressor to the various parts of the building, with valves for shutting off different branches, and regulating valves for each point of delivery. The pipes leading into the main tanks of the aquarium are of Sheradised iron, the nozzles also being of the same material. In all other parts the pipes are of heavily galvanised iron. All the valves are of bronze, heavily tinned, and made to the Admiralty specification. The delivery end of the valves is made to receive either a screwed pipe or rubber tubing.

This installation has now been running for a considerable time with great regularity, and it has proved itself to be in every way thoroughly effective. On tests being made, it was found that under normal conditions it consumed half an ampere of current at 480 volts, or less than $\frac{1}{4}$ horse-power, and the maximum current consumed when delivering 400 cubic feet of air per hour is only $\frac{3}{4}$ ampere.

These tests show considerable economy as compared with installations which compress the air to a high pressure in the first instance and require a 2-horse-power motor working from eight to twelve hours per day in regular use. The economy is effected partly by the fine division of air in the water, and also by the fact that the air is not compressed to a greater extent than is actually required.

# FAUNISTIC NOTES.

By B STORROW.

## ECHINODERMS.

*Luidia sarsi* (Düben and Koren) was taken in the dredge 35 fathoms S.E. of the Crumstone, Farne Islands, in September 1912. Between the Inner Farne and Bamburgh Castle *Strongylocentrotus droebachiensis* (Müller) has been found in large numbers, as many as 41 being taken in one haul in June 1912. *Antedon bifida*, Bell, two arms only, was found in the dredge in June of this year when dredging 6 miles E. of the Longstone.

## NUDIBRANCHS.

The following have appeared in the aquarium tanks of the Laboratory :—*Coryphella lineata* (Lovén) in February, *Galvina picta*, A. and H., and *Facelina drummondi*, Thompson, in April, and *Embletonia pulchra* (A. and H.) in May. The first-named has been recorded from this district before, being taken by the "Huxley" in 1907 from 45 fathoms E. of Coquet Island. *Galvina picta* was recorded from Cullercoats by Alder and Hancock, but this is the first specimen which has come within my notice in the past seven years. The others, as far as I know, have not been found before in this district, though *Facelina drummondi* has been recorded from Scottish waters, and also from the neighbourhood of the Dowsing Ground, about 50 miles E. of the Lincolnshire coast.

*Hermea dendritica*, A. and H. appeared in our tanks two years ago. At first it was only found in one tank, but this year it is to be found in every tank where green algæ are present in any quantity.

*Macandrevia cranium* (Müller). Four specimens of this brachiopod were given to me in March by Mr. Turnbull, skipper of the "Wild Rose," a North Shields trawler. Mr. Turnbull stated that large numbers, attached to small stones and shells were found in the trawl when fishing in 120 fathoms, 61° 14′ N. and 2° 45′ E.

*Calocaris macandreæ*, Bell. On May 31st of this year, Mr. Dunn, of Whitley Bay, had in his shop a small sturgeon, about 5 feet long, which had been caught by a local trawler 14 miles E. by N. of the Tyne. On examination of the contents of this fish's stomach, 120 specimens of Calocaris were obtained, as well as six Polychaets, Glycera sp., and one Tellina.

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*Trypetesa lampas* (A. Hancock). In March of this year Miss Roper drew my attention to the presence of a burrowing crustacean in the shells of *Neptunea antiqua*, which she was examining for Polyzoa. This proved to be *T. lampas*, and was found to be very common. The shells were obtained from local fishing cobles which had been fishing in 16 fathoms S.E. of St. Mary's Island.

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*Pectinaria auricoma* (Müller). This polychaet was found in numbers in the supply tank for the aquarium in March. The tank had been cleaned some nine months before. At the bottom of the tank were some four inches of mud and fine sand, and in this were the tubes of Pectinaria, with the apex of the tubes just below the level of the surface of the sediment. As well as Pectinaria there were numerous specimens of *Harmothoe imbricata*, together with *Phyllodoce maculata* and its egg-cases, *Amphitrite johnstoni*, one specimen of *Halosydna gelatinosa*, and the nudibranchs, *Coryphella rufibranchialis* and *Doris tuberculata*.

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## PERIDINIALES NEW TO THE DISTRICT.

*Dinophysis acuta*, Ehrenberg, has been found in surface catches from 6 and 17 miles S.E. and S.E. by S. of the Crumstone in August, September and October. It only occurred sparingly. Size, ·792 × ·055 mm.

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*Amphidinium rotundatum*, Lohmann, was found in the floor pool of the aquarium on the morning of the 20th of May, and disappeared in the afternoon. The floor pool overflows into the drain for the Laboratory. It occurred in such numbers that the surface of the water was streaked with yellowish-brown lines of colour. On the evening of the same day small numbers were found colouring the sand in Cullercoats Bay. During the two following days it also occurred in large numbers, and then it disappeared. Length, ·0105-·013 mm.

*Amphidinium operculatum*, Claparède and Lachmann. Small patches of sand coloured by *Amphidinium operculatum* were found by Professor Meek at the northern side of Cullercoats Bay on 25th May. These patches remained for some days, but with the advent of the spring tides they gradually disappeared. Length, ·035-·03 mm.